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COMMITTEE REPORTS AND DISCUSSIONS

REPORT OF COMMITTEE XV.—ON IRON AND STEEL STRUCTURES.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The following report is respectfully submitted:

Your Committee on Iron and Steel Structures held a meeting at Buffalo, N. Y., on January 4 and 5, 1911, the following members being present:

C. H. Cartlidge, Chairman;
A. J. Himes, Vice-Chairman;
J. A. Bohland,
C. L. Crandall,
A. F. Robinson,
I. F. Stern,
F. E. Turneaure.

The subjects assigned to your Committee for consideration this year were as follows:

(1) Revision of Manual.

(2) Report findings on effect of impact on bridges.

(3) Recommend specifications for bridge erection.

(4) Report on secondary stresses.

(5) Report on influence of theory, experiment and experience on bridge design.

(6) Rules for instruction and guidance of inspectors in mill, shop and field.

(7) Make concise recommendations for next year's work.

(8) Make definition of the word "culvert" as distinguished from "bridge."

In addition, the chairman was advised by the Board of Direction to hold a joint meeting with the Roadway Committee for the purpose of reconciling the specifications for clearances in bridges and tunnels. This meeting was held on December 30, 1910, in Chicago. Your Committee reported to the Board that it would recommend the insertion, in paragraph 2 of the specifications for Iron and Steel Structures as printed in the edition of 1910, after the word diagram in the second line, the following, "the height of rail shall, in all cases, be assumed as 6 in."

In the case of Subject (1), your Committee has no changes in the specifications to recommend, except that, as printed, there are certain typographical errors as follows:

In paragraph 50, second line, change "connection" to "connections."

In paragraph 53, third line, change "section" to "sectional."

In the second part, Material and Workmanship, paragraph 86, in the last line, column headed "Rivet Steel," change 185 degrees to 180 degrees.

In paragraph 97, in the last line, change paragraph 84 to paragraph 86.

In paragraph 109, in the first line, change "casting" to "castings."

In paragraph 138, in the third line, change "borings" to "boring."

Subject (2): in Appendix "A" will be found a report by the chairman of the Sub-Committee on Impact, covering the work which has been done, and which is proposed to be done during the coming season.

In Appendix "B" is a report from the Sub-Committee on Impact, concerning secondary stresses.

In Appendix "C" we submit specifications for bridge erection.

The time at the disposal of the Committee has not been sufficient to make a proper report on the other subjects put before it, and it is requested that they be referred back to the Committee for further consideration.

With regard to next year's work, your Committee would suggest the employment of a reporter on subjects connected with design and maintenance of steel structures, whose duty it will be to collate reports of prime interest and report them to the Committee, as information, which, after being considered and passed upon, may be laid before the Association to be printed in Bulletins, so as to be accessible to the membership. The cost of this work will be small and it is believed the work will be of great value.

The Committee recommends that a study of the design of large columns be taken up, and suggests that collaboration with an existing joint committee, appointed for the same purpose, would, perhaps, bring about valuable results.

CONCLUSION.

Your Committee recommends the adoption of the Specifications for Bridge Erection for publication in the Manual.

Respectfully submitted,

C. H. Cartlidge, Bridge Engineer, Chicago, Burlington & Quincy Railroad, Chicago, Ill., *Chairman.*

A. J. Himes, Engineer Grade Elimination, New York, Chicago & St. Louis Railroad, Cleveland, O., *Vice-Chairman.*

J. A. Bohland, Bridge Engineer, Great Northern Railway, St. Paul, Minn.

Charles Chandler, Bridge Engineer, Chicago Great Western Railroad, Chicago, Ill.

C. L. Crandall, Professor of Railway Engineering, Cornell University, Ithaca, N. Y.

J. E. Greiner, Consulting Engineer, Baltimore, Md.

B. W. Guppy, Bridge Engineer, Boston & Maine Railroad, Boston, Mass.

Chas. M. Mills, Consulting Engineer, New York, N. Y.

C. N. MONSARRAT, Engineer of Bridges, Canadian Pacific Railway, Montreal, Can.

C. D. PURDON, Chief Engineer, St. Louis Southwestern Railway, St. Louis, Mo.

A. F. ROBINSON, Bridge Engineer, Santa Fe Railway System, Chicago, Ill.

C. C. SCHNEIDER, Consulting Engineer, Philadelphia, Pa.

I. F. STERN, Engineer of Bridges, Chicago & Northwestern Railway, Chicago, Ill.

F. E. TURNEAURE, Dean, College of Engineering, University of Wisconsin, Madison, Wis.

J. R. WORCESTER, Consulting Engineer, Boston, Mass.

Committee.

Appendix A.

REPORT OF SUB-COMMITTEE ON IMPACT.

(Bulletin 125.)

Your Sub-Committee on Impact presents herewith a report covering the work of the past three years. This report is not to be considered a final one upon the subject, but the experiments which have been conducted have been fairly comprehensive except for long spans, and it is the intent of the Committee to present a report which shall include a full account of the tests, the detailed results and such a discussion of the same as appears to be warranted at this time. Results of other tests have been briefly noted but are not discussed. The subject of secondary stresses has not been touched upon further than to present a few typical results obtained as incidental to the main experiments.

The Sub-Committee is not prepared at this time to recommend a formula for general use in specifications. It has seemed proper, however, in presenting the results of the tests which have been made, to express the law of maximum impact, as thereby developed, by a formula, and this has been done. It should be noted that the impact percentages herein discussed relate to the variations in the axial stresses in the members, and do not include the element of secondary stress. The few results on secondary stresses noted herein, as well as measurements of such stresses by other experimenters, indicate that they are very important and require careful consideration in the selection of working stresses used in design. The element of secondary stress may or may not be included in a single formula with that of impact. This is a question which must be considered in making recommendations of an impact formula.

Respectfully submitted,

F. E Turneaure,
C. L. Crandall,
C. H. Cartlidge,
C. C. Schneider,
Sub-Committee on Impact.

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SECTION I. ACCOUNT OF THE WORK OF THE SUB-COMMITTEE.

I. ORGANIZATION AND HISTORY OF THE WORK.

The importance of the subject of impact and the lack of adequate information on this subject has been the cause of frequent discussions in this Association, and especially in its Committee on Iron and Steel Structures. Partly as a result of these discussions, but largely by reason of the interest shown by the individual members of this Committee, the chairman of your Sub-Committee undertook to construct an extensometer especially designed to make tests on structures in service with especial reference to the effect of moving loads. This instrument was described at the annual meeting of the Association in 1907 and a few diagrams shown which were obtained from it. On recommendation of the Committee on Iron and Steel Structures made at that meeting the Board of Direction authorized the soliciting of subscriptions from railroad companies to defray the cost of the construction of a number of such instruments and of an extensive series of tests. Pursuant to this action a fund of $5,631.74 was shortly subscribed by a large number of roads and the work authorized. A Sub-Committee was appointed, consisting of Messrs. F. E. Turneaure, C. L. Crandall and C. H. Cartlidge, to conduct the experiments.

The construction of the instruments was undertaken at the shops of the Engineering Department of the University of Wisconsin and eight were completed in time to permit of a short period of field work during the summer of 1907. With these eight extensometers and a deflectometer loaned by the University of Wisconsin, experiments were conducted for a period of about four weeks, the field party consisting of the members of the Sub-Committee, assisted by Messrs. W. S. Kinne and E. E. Parker, of the University of Wisconsin; Donald Derickson, of Cornell University, and A. D. Stewart, M. E. A progress report of the results of this season's work is contained in the Proceedings for 1908 (see Vol. 9, pp. 222-234).

During the season of 1908 the experiments were continued, twelve extensometers being available at this time. The Sub-Committee was enlarged by the addition of Messrs. C. C. Schneider and J. C. Bland. About nine weeks were spent in the field, the party consisting of Messrs. Turneaure and Crandall, of the Sub-Committee, assisted by Messrs. W. S. Kinne, E. E. Parker, O. L. Kowalke and J. B. Kommers, of the University of Wisconsin, and A. C. Irwin and E. W. Rettger, of Cornell University. The work of this season concluded the field work as planned, but it was found impracticable to digest the great mass of data and present a final report in time for the meeting of 1909. It was also found that the funds on hand were insufficient to provide for such a study and tabulation of the data as was desirable. At the request of the Committee on Iron and Steel Structures, at this meeting the Board of Direction proceeded to solicit further contributions, the result of which was the contribution of an additional fund of $4,206.10 A list of contributors will be found on pp. 48-50.

During the past year a few supplementary tests have been made on a long span bridge at Bellefontaine, Mo., but the work of the Sub-Committee has been mainly confined to the reduction and analysis of the data. They herewith present their final report, which concludes the series of experiments provided for. Ten of the extensometers are the property of the Association, the other two belonging to the University of Wisconsin.

The total expenditures to date have amounted to $7,167.62. This money has been expended mainly for railroad fare and other traveling expenses, salaries of assistants, and apparatus. Members of the Sub-Committee have been reimbursed for their traveling expenses, but have contributed their time gratis to the work. The expenditures have been distributed as follows:

EXPENDITURES.

Railroad Fare	$1,307.88
Other Traveling Expenses	1,295.69
Salaries of Assistants	3,026.95
Cost of Instruments	1,091.38
Supplies, Expressage and Incidental Expenses	445.72
Total Expenditures to date	$7,167.62
Amount of Fund	$9,837.84
Amount Expended to date	7,167.62
Balance of Fund on hand	$2,670.22

2. INSTRUMENTS EMPLOYED.

The deflectometer used was the same as was employed in experiments described in the Transactions of the American Society of Civil Engineers, Vol. 41, p. 411. The instrument itself is fastened to the bridge and connection to the ground is made by means of a wire attached to a heavy weight placed underneath the instrument. At the upper end this wire is made fast to the recording mechanism of the instrument, and the motion is by this mechanism multiplied by two. The movement produced is recorded by a pencil upon a moving strip of paper. The apparatus is very compact and can be readily fastened to any horizontal projecting plate or to a vertical flange. The instrument is illustrated in Fig. 1.

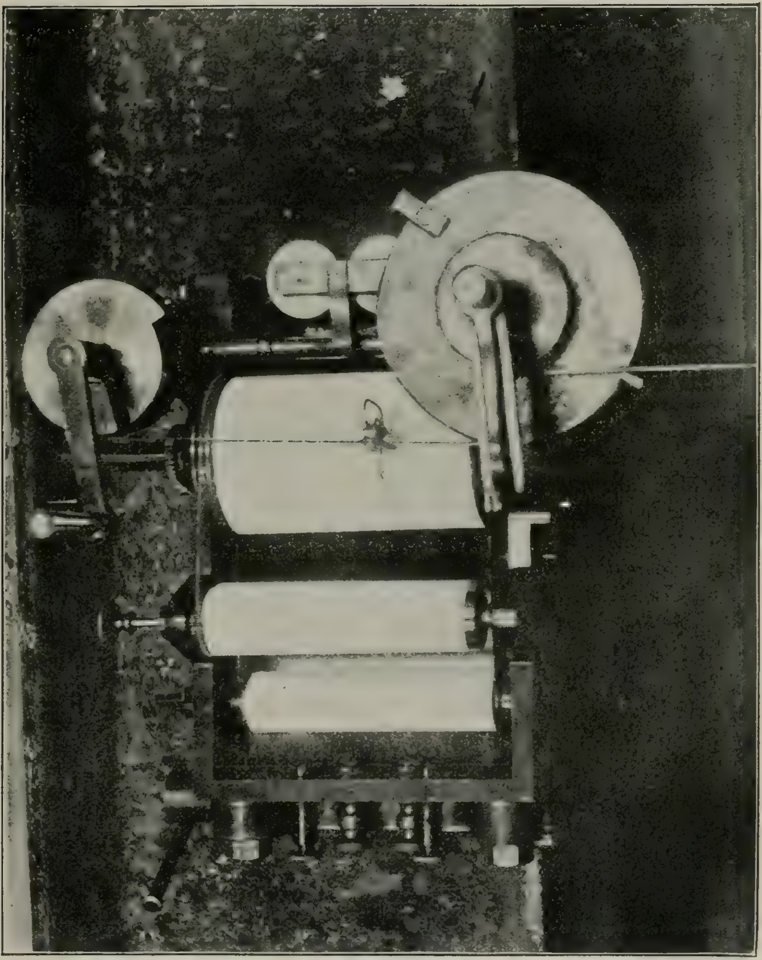

FIG. 1. DEFLECTOMETER.
(From *Trans. Am. Soc. C. E.*, Vol. 41.)

The extensometer is also an autographic instrument, the deformations being multiplied by a factor of about 50 and recorded upon a moving strip of paper. Fig. 2 is a drawing of the complete apparatus and Fig. 3 is a view of the recording mechanism. The frame of the latter part is clamped to an eye-bar or angle and another clamp is attached to the same member at a distance of about four feet from the first clamp. The latter clamp is connected to the recording apparatus by a light rod and a universal coupling. In Fig. 2 it is seen that there are two clamps at the instrument; the one at the left is rigid while the other is pivoted so as to allow of a slight rocking motion. A similar arrangement is made of the two jaws of the clamp at the outer end of the connecting bar. In the interior of the apparatus is a rod running from the long connecting rod to the short end of a lever, on which it has a knife edge bearing. The long end of the lever carries the pencil, which records its movements upon a traveling strip of paper driven by a train of clockwork. This lever is made of aluminum so as to be as light as possible, and is also very stiff. The clockwork is controlled by an electric circuit, thus enabling all of the instruments to be started and stopped simultaneously, if desired.

The results obtained from these instruments were, on the whole, satisfactory. The deflectometer, being a simple apparatus and with a low rate of multiplication, gave very reliable results. In the case of the extensometers the results obtained on such members as stringers and short span girders were frequently of little value on account of the vibrations produced in the instrument itself when subjected to the jarring action noticeable in such cases. Such effect sometimes occurred also on eye-bars, due to the vibration of the bar itself. In other situations, however, the results were generally satisfactory and reliable within the limits to be expected of such an apparatus. Typical records of the kind here referred to are noted further on.

The illustration of the instrument shows a length of four feet between the fixed clamps. This distance was, however, not a fixed distance, but was varied somewhat by means of an adjustable rod to suit the convenience of attaching the instrument to the bridge member. The exact distance was measured and recorded in each case.

The multiplication ratio of each extensometer is given in the calibration Table No. 1, together with the calculated value of the stress per square inch corresponding to a one-inch ordinate, assuming a modulus of elasticity of 30,000,000 lbs. per sq. in. and a length of 4 ft. between the fixed clamps of the instrument.

3. STRUCTURES TESTED AND RAILROADS ASSISTING IN THE WORK.

In determining upon a program of work it was assumed at the outset that the desired results could be secured only by the use of special test trains which could be available for several hours at any par-

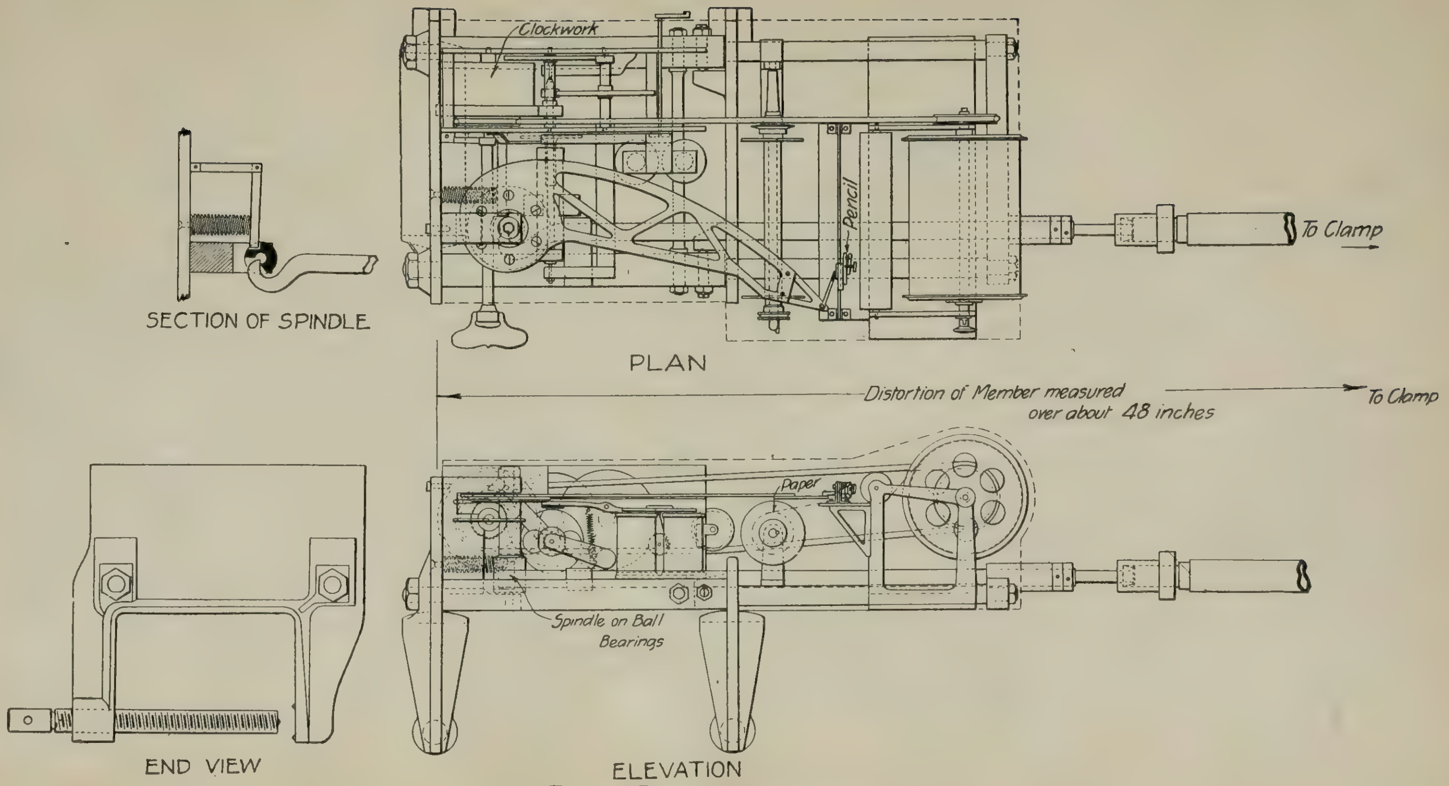

FIG. 2. BRIDGE EXTENSOMETER.

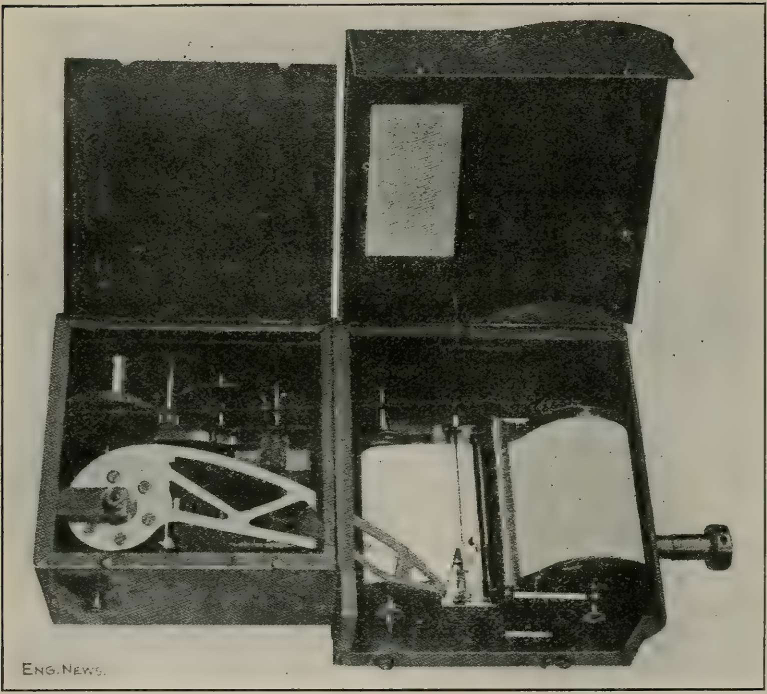

FIG. 3. (From *Eng. News.*)

ticular structure. To depend upon trains in regular traffic would, for several reasons, have been impracticable. This requirement involved large contributions in the way of track and train service on the part of the railways assisting directly in the work. However, the Committee takes much pleasure in recording the fact that during the three years over which the experiments have been extended, the facilities offered by various railroad companies have been much greater than could be utilized, and desires to extend its thanks to the many officials who have shown so large an interest in this work. Limitations of time, convenience of location and the nature of the structures available led finally to the carrying out of tests on the following roads: Illinois Central; Chicago, Burlington & Quincy; Chicago, Milwaukee & St. Paul; Chicago, Rock Island & Pacific; New York, Chicago & St. Louis; Atchison, Topeka & Santa Fe; Pennsylvania Lines; Norfolk & Western, and New York Central. In all cases these roads furnished, free of charge, a special test train and all needed assistance in the way of laborers and mechanics. Every effort was made to facilitate the task, and the thanks of the Committee are due, the several managements for the valuable courtesies extended.

The number and kind of structures tested included 21 plate girder spans and 24 truss spans, classified as to length as follows:

Plate Girders:	No. Tested.
Under 50 feet	7
From 50 to 75 feet	8
From 75 to 100 feet	6
Truss Spans:	
Under 100 feet	1
From 100 to 150 feet	12
From 150 to 200 feet	6
From 200 to 250 feet	3
Over 250 feet	2

The location and character of the several structures are fully given in Tables 2 and 3 and by the skeleton diagrams on Plates Ia, b, c, etc.

4. TEST TRAINS.

The test train used in each case was made up of a selected type of locomotive, followed generally by a sufficient number of loaded cars to cover the span. Long trains were not used for the reason that it was desired to secure speeds as high as practicable. By the arrangement adopted, speeds of 60 miles per hour or over were generally obtained even with freight locomotives. In some cases loaded cars were not used, but only a caboose, or coach and caboose, following the locomotive. In these cases the results would have been little affected by a heavier load. Data relative to the locomotives and test trains used are given in Tables 4 and 5. The data relative to weight of overbalance are important. The weights given were obtained from the engineering departments of the several railroad companies and represent in each case the excess weight over and above the weight necessary to counterbalance the rotating parts, and calculated as at crank-pin center. The Committee was fortunate in being able to use several balanced compound locomotives for the tests. These types afforded a very valuable comparison with the usual simple or ordinary compound locomotive.

5. GENERAL METHOD OF CONDUCTING THE TESTS.

In the case of truss bridges it was the aim of the Committee to secure data relative to the deflection at or near the center of the span, and the deformations in all the various kinds of members. With the 12 extensometers in use it was possible to cover the various kinds of members reasonably well with a comparatively few changes of instruments. Generally the tests on the upper and lower chords were confined to one panel, but in most cases at least two of the eye-bars composing a chord member were tested. The same thing is true of diagonal members composed of eye-bars. In carrying out the tests the train was headed in the more favorable direction for speed, and was moved back and forth over the structure at various rates of speed. Such speeds were selected as to cover fairly the range from about 20 miles per hour to the maximum attainable. A few movements were made at from 10 to 15 miles per hour. Little difference was noted in the results at various speeds below 15 miles per hour, and, in general, the results at 10 miles per hour may be considered as practically equal to static stresses. The speed of the train was determined by the use of stop-watches and signals made by observers stationed at the ends of a 500-foot base line. (In the case of very high speeds a 1,000-ft. base line was used.) The locomotive was generally working steam when crossing the span, but in some cases it was not. Differences in this respect caused no noticeable differences in results, so far as the field observers were able to judge, although this point was considered mainly with respect to the higher speeds.

A considerable variation in weight of tender would occur during a series of tests, due to variation in amount of water and coal present. To allow for this effect a slow-speed test was generally run just before and just after taking water, in order to secure records for "static" stresses from which could be interpolated proper static stresses for intermediate runs with which to compare the results at higher speeds. It was the purpose to secure data, so far as possible, that would give the desired information by direct comparison only and without depending upon calculations. While it would be possible to calculate the static stresses from the known weights, such a procedure would be exceedingly tedious and involve many uncertainties, due to secondary stresses, unequal pull of bars and lack of uniform behavior of the instruments.

By using the identical train load at various rates of speed these difficulties were largely obviated. The calculations which have been made are therefore, in general, simply a comparison of the deformations at high speeds with those occurring at such low speeds as to be considered as static effects. Experience in conducting the tests soon made it evident to the Committee that at such a speed as 10 to 12 miles per hour no appreciable impact effect occurred. In the reduction of the data great care has been taken in deciding upon a correct value for the static deformation, since a small variation in this value, in the case of low stresses, would cause a large variation in the percentage excess shown by the higher speed tests.

While incidental to the main purposes of the tests, the Committee secured many results bearing upon the subject of secondary stresses. These are discussed briefly under Section VI.

SECTION II. DETAILED RESULTS OF THE TESTS.

Table 6, including sixty-five sheets of data, contain the detailed results of the tests so far **as** they can conveniently be represented by measurements of the diagrams. The several tests are numbered consecutively, all diagrams obtained on any one test being given the same number and also a number corresponding to the number of the instrument. The diagrams obtained from the deflectometer are labeled "D." These sheets contain the following information:

The first column gives the number of the test, the second column the speed in miles per hour and the third column the position of the marker on the locomotive driver referred to a fixed point of reference on the structure. This point of reference is noted on the diagram by a cross. Following these columns of general information are data obtained from the several instruments, namely, from the deflectometer and from the 12 extensometers. For each instrument is given, first, the location of the instrument on the truss (also shown approximately on the skeleton outline at the top of the sheet). Then follow three or four columns of data. The first column gives the maximum ordinate to the curve in hundredths of inches; then the value of the maximum ordinate for slow speed or static load; then the percentage excess of the maximum over static; then, in many cases, a column headed "R," or "Remarks." Under the column of "Remarks" is indicated in a general way the character of the diagram obtained. For this purpose the letters "I" and "M" are used to indicate, respectively, "Instrumental vibration" and "Member vibration." By instrumental vibration is meant that the diagram is affected more or less by vibrations of the extensometer itself as indicated by vibrations of very short period. Where these are excessive the expression "I +" is used, and in such cases the value of the maximum ordinate is not reliable. By the letter "M" is meant that the diagram is affected by the vibration of the member itself, which, although involving a certain definite variation in stress in the member, should not be considered as a variation in the axial stress. The subject of member vibration is considered separately under Section VI.

These sheets contain all of the essential data from which the information contained on subsequent sheets has been obtained. The static or slow-speed values have been very carefully determined by an inspection of slow-speed records and by interpolation, where necessary. In measuring maximum ordinates care has been taken to eliminate instrumental and member vibration so that the results will indicate as nearly as possible the axial stress in the member. The direction of the forward motion of the train and other data are given at the top of each sheet.

To make clear the meaning of the tabular values given in these sheets, several typical diagrams are reproduced in Plates II a, b, c, etc. On each diagram from a to j is shown the approximate ordinate for slow speed or static load by means of a straight line with a short horizontal line at the extremity. Plate II a shows results obtained from tests at slow or moderate speeds. Plate II b shows results obtained at higher speeds, in which there appears little effect of instrumental or member vibration. The large vibrations indicated on the deflectometer and extensometer records correspond with each other and are due to the vibration of the structure as a whole, producing corresponding variations in the stresses in the members. Diagrams 892-6 and 892-2 show some instrumental vibration, and the upper diagrams on Plate II d and some of those on Plate II g show very excessive vibrations, due to this cause, which are so large as to make it impossible to determine what the axial stress really is. Diagrams 943-7, 951-7 and 912-4, Plate II d, illustrate the effect of member vibration on extensometer records. This vibration is very much slower than the instrumental vibration, but is generally much faster than the vibration of the truss itself.

The original records have been pasted into large blank books in consecutive order and these are filed in the Secretary's office, where they may be examined by anyone interested.

SECTION III. DISCUSSION OF RESULTS.

I. CAUSES OF IMPACT IN GENERAL.

The following may be enumerated as the chief factors in causing impact: (1) Unbalanced locomotive drivers; (2) rough and uneven track; (3) flat or irregular wheels; (4) eccentric wheels; (5) rapidity of application of load; (6) deflection of beams and stringers, giving rise to variations in the action of the vertical load.

The term "impact" is here used to include any effect of the moving load which results in stresses exceeding the static stresses. Where caused by open joints or rough or flat wheels, this impact is more or less of the nature of a "blow" upon the structure; but where caused by the other factors mentioned, it amounts in effect to a varying load or a series of impulses acting upon the structure. In either case the result is to produce deflections and stresses in excess of the static values, such excess of stress being commonly called "impact" stress, or simply "impact."

The experiments obtained in this series of tests, as well as the results obtained in former tests, indicate that with track and rolling stock in good condition the main cause of impact is the unbalanced condition of the drivers of the ordinary locomotive. Various rules are in use for the balancing of locomotives, but, excepting in the balanced four-cylinder locomotive, or the electric locomotive, it is impracticable to balance an engine in all respects. The result aimed at by the mechanical departments is to so counterweight the wheels as to secure a reasonable compromise between the effect of the rotating parts and the reciprocating parts. This requires the use of counterweights considerably in excess of the amount necessary to balance the rotating parts. So far as the vertical effect on the track is concerned the reciprocating parts are of little influence, but by whatever amount the rotating parts are overbalanced, just so far will there be a variation in pressure upon the rail due to the centrifugal force of such overbalance. The actual amounts of such overbalance are given in the data for the several locomotives used (Table 4). It will be seen that these excess weights amount to a considerable fraction of the weights on driving axle, and at high speed the centrifugal force becomes a large percentage of the vertical load. To show the relative importance of this there are given in Table 7 the calculated amounts of the centrifugal force of the excess weights for the various locomotives, at a speed of 60 miles per hour, in terms of percentage of weight on the drivers. Account is taken of the fact that the counterweights are 90 degrees apart on the two sides of the locomotive and the resultant effect is here given. This centrifugal force amounts to about 60 per cent. of the vertical load in some cases. At 80 miles per hour this would be over 100 per cent. The great variations in the values of this table suggest that it would be desirable to consider whether or not the practice in some cases might not be modified so as to reduce the vertical effect and still leave the reciprocating part sufficiently balanced.

In consequence of the action of these centrifugal forces during the passage of a train, the load acting upon the bridge is a varying one. It varies with each rotation of the driver, and thus acts as a series of impulses tending to set the structure into vibration. In the case of short span bridges these impulses will be repeated only two or three times during the passage of the locomotive, but in the case of long span bridges they will be repeated many times. If now these impulses correspond in period with the normal rate of vibration of the loaded structure, the effect will be cumulative and the vibrations will be greatly increased. Such cumulative effect cannot occur for bridges of very short span length, as the normal rate of vibration of such structures is higher than the rate of rotation of the drivers at the highest practicable speeds. It may and frequently does occur in structures of span lengths as low as 75 feet and sometimes less. The speed at which the impulses here discussed show a cumulative effect may be termed the *critical speed*. This is discussed more fully in following paragraphs.

Other causes of impact are less readily studied than that of locomotive counterbalance. The condition of track and wheels can be defined in rough, general terms only. The effects of these elements, as shown by the tests, were also in most cases such as to make it difficult to express them quantitatively. In some cases the behavior of the loaded cars was such as to cause large impact. This will be discussed more fully in following paragraphs.

The effect of the locomotive counterweights was found to be of such great relative importance that this element will be discussed first.

2. TIME OF VIBRATION OF BRIDGES.

In Section VII is given a theoretical deduction of a convenient formula which expresses the time of vibration of a loaded bridge in terms of weight of structure and its load, and the static deflection due to the live load. The formula is as follows:

$$T=\sqrt{\frac{w+p}{p}\times d},$$

in which $T=$ time of vibration of loaded structure in seconds;
$w=$ dead load per foot, assumed as uniform;
$p=$ live load per foot, assumed as uniform;
$d=$ static deflection in feet due to load p, as determined by direct measurement.

This formula corresponds very closely with that derived by Professor S. W. Robinson,* but is derived in a different way. His formula for a uniformly distributed load is

$$T=2\pi\sqrt{\frac{2w}{3gp}\times d}$$

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*Trans. Am. S. C. E., Vol. 16, p. 42.

In Table 8 are given the values of critical speeds as calculated from the first formula above given. The observed critical speeds are also given, these being the speeds at which the vibrations were cumulative. The correspondence of calculated and observed values is very close. The correspondence of period of vibration with driver circumference was also checked by measuring the distance on the diagram between successive vibrations.

3. CRITICAL SPEEDS.

The speed of the train which will produce cumulative vibration, as described above, depends upon the natural rate of vibration of the loaded structure and the diameter of the locomotive drivers. During the passage of a train the total weight on the structure varies to a considerable extent and hence the normal rate of vibration of the structure also varies. Exact agreement, therefore, between driver rotation and vibration period of the structure will exist only for a short time, and hence the cumulative effect will not continue during the passage of the locomotive entirely across a long span structure. The diagrams show very clearly the effect of this cumulative vibration and also, in many cases, how this cumulative vibration is broken up after four or five periods by lack of exact synchronism between driver rotation and rate of vibration.

In Table 8 are given complete data, so far as possible, relative to the critical speeds as actually observed for the various bridges and locomotives.

On Plate IIb are shown several diagrams of interest in this connection. Diagrams 890 show the results obtained on a 300-foot span due to the passage of a locomotive at just the right speed for maximum effect. Diagram 890-5 is a diagram from one of the chord members for this same test. Diagrams 892 show a common case of a broken-up vibration due to the fact that the movement of the train was at a speed slightly higher than the critical speed. The effect was cumulative for a short time, but the vibrations were soon broken up by the lack of synchronism. Plate IIf shows additional diagrams illustrating these points.

On plates IIIg, i, p, an, and ap, are given further data relative to critical speeds. These diagrams show the impact percentage for a range of speed on several structures. It will be observed how the impact percentage (due mainly to vibrations) increases with speed up to a certain point, which is the critical speed, and then rapidly falls off. Plates IIIbj and bq are diagrams showing results on short span plate girders for which the highest speed employed was still below the critical speed.

The results here given show clearly the importance and significance of critical speed on all bridges exceeding about 100 feet in span length. In all such spans it was found that the excess of deflection or stress at high speeds, over the static effects, was due almost wholly to cumulative vibrations, produced at or near this critical speed.

4. LAW OF IMPACT AT CRITICAL SPEED.

In Section VII a theoretical analysis has been made of the ideal case of the effect of a rotating weight upon the deflection of a beam when such rotation is in phase with the vibration period of the beam itself and therefore produces cumulative effect. It is there shown that in this ideal case the amplitude of deflection due to the centrifugal force of such rotating weight is given by the expression $x = 2\pi n \frac{Gr}{2W}$ in which G=weight of arm r=arm of rotating body, W=weight of beam, assumed as concentrated at the center, and n = number of revolutions of weight from beginning of motion. The effect of friction or other resistance in absorbing the energy is not taken into account in this theoretical analysis.

The case of a bridge supporting a rolling load consisting of unbalanced wheels is somewhat similar to the theoretical case here analyzed. The masses are distributed instead of being concentrated and the absorption of energy prevents the development of vibration to the extent assumed by the theory, but the relations brought out in the analysis may be useful in interpreting results. Where the rotating wheels synchronize with the natural period of vibration of the loaded structure then the vibrations will be cumulative somewhat as assumed in this analysis.

We would then conclude that the amplitude of vibration in such a case would be proportional to the moment of the counterbalance and inversely proportional to the weight of the loaded structure. Such vibrations would also increase in amplitude with the number (n) of impulses due to the rotating weight. Obviously the amplitude will not increase indefinitely as the impulses are repeated, but will soon reach a maximum limit where the energy absorbed balances the energy applied by the rotating body.

The impact *ratio* or percentage, due to cumulative vibration, is equal to the maximum amplitude of vibration, divided by the static deflection d, or theoretically,

$$I = 2\pi k n \frac{Gr}{2Wd} = k^1 n \frac{Gr}{Wd},$$

in which k^1 is some coefficient which takes account of the absorption of energy. The deflection, d, of a structure, designed under given working stresses, is approximately proportional to $l \times \frac{p}{w+p}$, in which p = live load and w = dead load per foot; and the number of impulses which will occur during the passage of a locomotive = l/c, in which c = driver circumference. Hence, we have the approximate relation that I varies with $k^1 \frac{Gr}{pcl}$; that is, the impact percentage at the critical speed varies with the moment of the counterweight and inversely with the live load for which the structure is designed, the circumference of the driver, and the span length. The coefficient k^1 is also doubtless a variable. The impact percentage thus appears to be independent of the weight of the structure itself. This is explainable from the fact that the critical speed is here assumed, and, further, that while the absolute vibration will be less for heavy structures the static deflection from live load will also be less so that the percentage will tend to be constant.

To enable a study to be made along the line of this discussion the quantity $\frac{Gr}{c}$ has been calculated for each locomotive and entered in Table No. 8, where it is called the "Locomotive Coefficient." The results in general show large impact for high values of the coefficient but not in proportion to it. The variation in maximum impact percentage is much less than in the value of this coefficient.

5. VIBRATIONS UNDER BALANCED LOCOMOTIVES.

The great importance of unbalanced drivers and the significance of cumulative vibration is well brought out by a comparison of the results already discussed with the results obtained from balanced compound and electric locomotives. In some cases the balanced compound locomotives appeared to be not well balanced, but in other cases the balance was remarkably good as shown by the experimental results. On Plate IIe are shown several such results, both from deflections and from stress, and Plates III, ag, ab, am, and bw give the results obtained on several structures at all speeds. These curves are very valuable and significant as showing how small the impact may be under balanced loads with a smooth track, and bring out forcibly the relative importance of counterweights as the prime factor in causing impact.

6. MAXIMUM IMPACT PERCENTAGES FOR TRUSS SPANS.

On Plate IV are plotted the maximum impact ratios from deflections for all spans irrespective of speed or type of locomotive. In most cases these spans were of sufficient length so that the critical speed was obtained. On Plate V are plotted similar maximum ratios obtained from extensometer measurements on what are here called "main truss members." These values are obtained by averaging in each case the maximum results from chord members and end post. They are thus averaged for the reason that all of these members receive their maximum stress for a fully loaded structure. The results agree closely with each other, as should be expected. While the individual results vary somewhat, it is thought that an average value for these members will be more significant than the maximum obtained from any one. The extensometer measurements are affected more or less by secondary stresses, and the instruments themselves are not quite as reliable as the deflectometer, so that, on the whole, an average value for these main truss members was considered to be a fair measure of maximum impact for all similar members. It will be seen that the impact values determined from these main members are somewhat greater than the values determined from the deflection records. This is to be expected, partly on account of the effect of secondary stresses, and partly on account of the fact that the deflection itself represents in a measure an average of *all* of the truss members, and should be somewhat less than the average of a few members. The relative values for deflection and stress in main truss members are discussed more fully in a later paragraph.

7. MAXIMUM IMPACT PERCENTAGES FOR PLATE GIRDER SPANS.

For spans of such length that the critical speed is higher than the maximum speed employed, the impact values increase generally with the speed. Plates III, ar, bj and bg show several diagrams of impact percentages, based on deflections, which bring out very clearly this fact. The theoretical analysis given in Section VII for cases in which the impulse does not synchronize with the vibration period of a structure shows that in general the amount of impact is proportional to the centrifugal force and inversely proportional to the weight of the loaded structure and its span length. For cases in which the impulses are applied at a rate approaching the normal period of vibration of the structure the vibrations will be cumulative to a certain extent. From these considerations we should expect that for very short spans the impact would not vary greatly with length of span and that for spans from 40 to 80 or 100 feet the impact values would gradually merge into those obtained for the long span structures.

Besides the observations made on plate girder spans the observations made on stringers, floor beams and hip verticals have been considered in the same class as those on short span structures. The stringers are nothing more than short span girder bridges, with the exception that the end supports are not generally as rigid as masonry piers. The floor beams may fairly be compared with plate girders of a span length equal to two panels, and the hip verticals must, of course, receive the same loads as the floor beams.

On Plate VI are plotted the impact percentages as determined from deflections on all plate girder spans. On Plate VII are plotted impact percentages for plate girders as determined from flange stresses, using average values. Plate VIII gives the results obtained on stringers, floor beams and hip verticals. The span length assumed in the case of the last two series is taken as equal to two panels.

8. COMBINED DIAGRAM FOR ALL BRIDGES.

Plate IX contains all of the data given on Plates V and VII, namely, the impact percentages as determined from stress observations on plate girders and main members of trusses. It will be seen that the values for short spans apparently introduce no sudden change in the law of impact variation. Comparing with Plate VIII it is also seen that the results on stringers, floor beams and hip verticals are somewhat lower, if anything, than the results obtained on plate girder bridges. Plate IX includes perhaps the most important results obtained in the entire series of tests, and if these results can be considered as fairly indicative of the maximum to be expected in ordinary circumstances, they constitute a very important basis for determining the law of impact. Before attempting to discuss such a law, however, it is desirable to consider certain other elements of the problem.

9. IMPACT PERCENTAGES ON VARIOUS TRUSS MEMBERS.

A very important phase of the question relates to the relative impact on the various members of the truss. Many observations were made to secure data with reference to this point. These observations related primarily to the various web members, excepting the hip verticals, these being already classed with the short span structures. The results obtained on the various truss members are shown by the diagrams of Plate X. These diagrams are plotted so as to show the impact percentages for each bridge, as determined, first, by the deflection; second, by the average result on main members (chord members and end posts), and third, by the results on various web members. The percentages determined under the third head are plotted in the order of the particular member in question, beginning at the end of the bridge. For example, on Plate Xc, bridge No. 24, 149-foot span, we have the several percentages for deflection, main members, main diagonal (first diagonal), second diagonal, third diagonal and counter. Also on the same plate, bridge No. 26, 300-foot span, we have eight different members, besides the deflection and the average for main members. These eight members are the several diagonals and the several vertical posts, the latter being numbered as "second panel post," "third panel post," etc. The second panel post and the second diagonal may be considered as having theoretically the same stress; likewise the third panel post and the third diagonal, etc. In several cases, where the results of two or more series of tests on the same structure with different locomotives were practically the same, the maximum results of the several series have been averaged and taken as representing better the results to be expected from such structure and locomotive than any single result.

These diagrams are of great importance as they give in graphic form all of the data relative to this feature. It will be noticed at once that if we begin with the average of main members, which is generally somewhat higher than the deflection percentage, the impact ratios, as we approach the center of the structure, do not generally vary greatly or in any constant way. In some cases, where a large number of members were experimented upon, there seems to be little change one way or the other. There is a decided tendency for the percentage for the main diagonal to be less than the average for main members. This is probably due to the fact that the actual static live load stresses in the chord members and end post were considerably less than in the main diagonals, and any accidental variation in the extensometers would therefore tend to increase the percentages as calculated for the main members more than it would for the main diagonals. Generally speaking, where the static live load stresses are very low the impact percentages become less reliable and are likely to be too high as calculated from the curves.

To determine, if possible, the general tendency of these curves certain other averages have been calculated and are given in Table 9a. These averages are determined as follows: The values in column 3 are the averages of the percentages for the main members and the main diagonals; the values in column 4 are the averages of the percentages for all of the other web members. These two sets of averages represent in a way two groups of members, one of which receives its maximum stress when the bridge is fully loaded, or nearly so, and the other when the bridge is loaded for from half to two-thirds of its length. In the fifth and sixth columns are given the differences between the two results, plus and minus. The total net difference and percentage difference, amounting to + 7.9 per cent., is given at the foot of the table. A similar calculation is given in Table 9b, comparing averages on main members with averages on all web members, including main diagonals. The results here show a slight tendency in the opposite direction. To make a further comparison a few of the results obtained from experiments made under the most favorable conditions have been selected and separately tabulated at the end of Table 9a, and in Table 9c. Some of the results in the other tables are omitted because of the small number of tests on the web members.

These calculations show quite clearly that there is little difference in the impact ratios for the different truss members tested. The slight average difference which indicates some excess on web members may easily be accounted for by the fact that for those truss members toward the center of the span the disturbances of instruments due to the vibrations in the individual members, especially in the case of eyebars, were on the average considerably greater than in the case of the main members and main diagonals. All such disturbances tend to increase the errors and the calculated percentages.

The results here shown were hardly expected, it being supposed that members near the center of the structure would receive materially greater impact than the chords and main diagonals. However, a careful analysis of the conditions in the light of the discussion on critical speed will show that the results are reasonable. The conditions under which the impact ratios for a long span truss are a maximum require a certain critical speed within quite narrow limits. A speed greater than this will give rise to vibrations which are noncumulative and hence smaller. It is also an observed fact that this critical speed, at which the vibrations are highly cumulative, causes the maximum impact not only in the main members but also in the web members. That is to say, the speed of maximum impact is practically the same for all members of the bridge, excepting the hip verticals and the floor system Under these conditions the behavior of the web members of a long span bridge is quite different from that of the main members or flanges of a short span bridge. Thus, in a 200-foot span the maximum impact percentage for all truss members, including counters as well as main members, will occur at a speed of say 35 miles per hour, while the speed of maximum impact for a girder or truss of 100-foot span will occur at a speed of 50 miles per hour or more. It is therefore not possible to compare the impact on the counters of a 200-foot span bridge with the impact on the main members of a 75 or 100-foot span.

There is one condition under which the impact ratio for web members near the center of a truss might be greater than the percentage for main members. This is the case where the speed of the train is a little too high to cause the greatest cumulative effect for the entire structure. Such a speed will cause cumulative vibration until the train has passed perhaps half way across the structure. The vibrations will then be broken up and will not be particularly great at the instant when the bridge is fully loaded. Such speeds will not give a maximum impact percentage for main truss members, but may give quite high values for the web members which happen to receive a maximum stress when the structure is half loaded. An illustration of such conditions is given in the diagrams on Plate IIf and IIh. Diagrams 623 on Plate IIf show how the vibrations are broken up before the maximum stress is reached in the main members (top chord and deflection), while for the same tests the vibrations are of large amplitude just at the time when the diagonal has its maximum stress. For these particular tests the impact percentages for the diagonals will be greater than in the main members. Other diagrams show similar conditions. From a casual inspection of records during the progress of the field work it was thought that these conditions would lead to somewhat higher values for web members than for main members, but in working out the actual percentages for the maximum values in each case the results are as shown in the diagrams already described. The differences in maximum percentage are in reality very small.

10. EFFECT OF POSITION OF COUNTERBALANCE.

In conducting the tests the position of counterbalance with reference to a particular point on the structure was generally determined. This was done by inserting an index consisting of a small steel pin into the rim of the locomotive driver directly opposite the counterbalance. Then along side and just outside of the rail a scantling was fastened to the ties and on the top of this a ridge of clay or putty was placed, into which the index would press and leave a mark which could be referred to a definite point of the structure. This arrangement proved very satisfactory and records of this sort were obtained on most of the structures tested.

It is not to be expected that the exact position of counterbalance would have any appreciable effect on spans of any considerable length, but on short-span girders, whose length does not exceed two or three times the circumference of a driver, it would seem that there would be an appreciable difference in impact whether the counterbalance happened to be down or up at the time when the drivers were centrally located on the span. To assist in studying the effect of this element, the diagrams on Plates XI have been prepared. The lower curve in each case shows the percentage impact and the upper curve the location of the counterbalance expressed in feet distant from the center of the span at the time when the counterbalance is in its lowest position. Theoretically, this position should give the maximum impact. An inspection of these diagrams shows a marked tendency to follow this law although the variations due to other causes are so great as to mask this effect to a large extent.

II. EFFECT OF SPEED OF APPLICATION OF LOAD.

Assuming the track perfectly smooth and all of the rotating parts perfectly balanced, the effect of a load moving over a structure at a high rate of speed depends wholly upon the vertical curvature of the track and the effect which this curvature has upon the path over which the center of gravity of the load travels. If the load causes the structure to deflect so that the curvature of the track is concave upward, the pressure of the load upon the bridge will be in excess of its weight by reason of the centrifugal force caused by such curvature. If the track has an initial camber so that when the load passes over the structure the deflection produced is just sufficient to bring the track into a straight line, then there would be no centrifugal force developed and the pressure of load upon the track will be constant and exactly equal to the static load. The impact in that case will be zero.

If we assume the track originally straight and absolutely rigid, the amount of impact or centrifugal force resulting from the deflection of the structure can be approximately determined on theoretical grounds. Such an analysis has been made by Dr. H. Zimmerman for the case of a single rolling load, and a formula which is very closely approximate to his exact formula is as follows:

$$F = P\frac{1}{gl^2/16\,v^2d - 3}$$

in which F = centrifugal force, P = weight of rolling load, v = velocity in feet per second, d = deflection of structure and l = span length.

If, for example, $d = 1/2400$ of span length and $v = 90$ ft. per second (about 60 miles per hour), we have

$$F = P \frac{1}{0.595\, l - 3}$$

a formula which is practically exact for spans greater than 15 feet. For a 25-foot span this gives 8.7 per cent. impact, and for a 50-foot span 3.7 per cent. For a 100-foot span the value would be 1.7 per cent.

Considering these results and the fact that for spans of any considerable length the track is cambered, and the abutments not rigid, we may conclude on theoretical grounds that the impact due to speed of application for spans greater than 50 feet is of no consequence.

The experimental data with reference to this point are very difficult to obtain by reason of other elements which are always present. The results obtained from balanced compound locomotives and electric locomotives are, however, very significant and indicate that under very favorable conditions as to track and rolling loads the impact is of very little consequence even for short spans. The results shown on Plate XII for span lengths of 149 ft., 300 ft., 70 ft. and 50 ft. are perhaps the most significant in this connection.

12. EFFECT OF ROUGH TRACK.

The effect of low or open joints in the track was directly noticeable on stringers and short span girders, and sometimes on floor beams and hip verticals where the rail joints were near the floor beam. It was not noticeable on main truss members or long span girders. The effect produced was, however, very difficult to determine quantitatively. Under these conditions the extensometers were so jarred and shaken up as to make the diagrams unreliable. The character of some of the diagrams produced under such conditions is illustrated in Plate IIg.

13. EFFECT OF DESIGN.

The most noticeable effect of differences in design is to be seen in the results obtained on stringers and floor beams. The extreme condition of rigidity is illustrated in the results obtained in bridge No. 5 where the rail was supported on steel channels riveted directly on closely spaced crossbeams, and these in turn into the lower chord of the truss. No observations were here made on the crossbeams, but the records obtained on hip verticals, examples of which are shown on Plate IIg, indicate a very severe jarring effect transmitted from the rail into the floor system. Many similar results were obtained with the ordinary open floor where the stringer spacing was such as to bring the rail nearly over the stringer. In this case the ties would afford but little elasticity and the jarring effect resulting from rough track or wheels was very noticeable in nearly all such cases. Where the stringers were widely spaced the elasticity due to long ties relieved this jarring effect very greatly and in most cases gave records nearly or quite free from instrumental vibration.

The effect of a ballasted floor on the results obtained on floor beams was even more marked than that of widely spaced stringers. Curves obtained from crossbeams and short-span girders having ballasted floors are illustrated in Plate IIi. In nearly all cases these were steady and reliable.

The most noticeable effect of elasticity of bridge floor was freedom from jar as shown by lessened instrumental vibration. The actual effect on impact percentage is very difficult to estimate because of the unreliable character of the records taken on the more rigid floors.

The effect of length of panel was not detected although the deflection of the stringers undoubtedly has some influence on the cumulative vibration when the panel lengths correspond approximately with the driver circumference or the car length. In modern designs, however, the stringers are made of such depth that their deflection under very heavy load will not generally amount to more than 1/10 or 1/12 inch. Compared to this the center of gravity of that part of the locomotive resting upon the main drivers will have a vertical movement of from ½ to 1 inch as the load moves forward, due to the excess counterweight. So far, therefore, as the locomotive is concerned the deflection of stringers when the length corresponds exactly to the circumference of the driver is of minor importance as compared to the effect of the counterweights.

The effect of design on main girders and truss members is difficult to determine. In considering this problem it should be kept in mind that the main factor in causing impact or excess of stress in main girders and truss members is the cumulative vibration set up by the unbalanced locomotive drivers. This effect cannot be eliminated by the most perfect design for the reason that the structure is an elastic body and subject to deflection and vibration from such causes as here considered.

Consider, first, two designs, one of which is an old light structure designed for a light load, and the other is a modern heavy structure designed for a heavy load. If the same locomotive be now moved over these two structures the centrifugal force of the counterweights will be able to produce larger vibrations in the light structure than in the heavy structure. At the same time the *static* deflection of the light structure will be greater than that of the heavy structure so that the *percentage* effect tends to be the same. In fact, if the light structure contains loose joints, and if its members are caused to vibrate individually more than those of the heavy structure, it is reasonable to expect that the energy which causes the vibrations is dissipated more rapidly in the case of the light structure than in the case of the heavy structure. This condition tends to reduce the cumulation of the vibration in the light structure. We should not expect, therefore, that the percentage impact on the main members of a light structure, as shown by the axial stress, will be greater than for a heavy structure. This fact is brought out by a comparison of the results obtained on bridges Nos. 32 and 34 of the Norfolk & Western Railway, which were relatively old and light structures, with the results of most of the other tests. (See Plate IV, results marked "W.")

Consider, again, two designs, both modern, designed for the same working stresses, but having different depths. The deeper structure will have less static deflection and will probably be of less weight. Its mass will therefore be more readily affected by any given impulse than the heavy structure, and it also has a smaller static deflection. The impact percentage in such a case is therefore likely to be greater for the light structure than for the heavy structure.

Again, it is to be noted that anything which decreases the rate of vibration of a structure tends to reduce the impact by reducing the critical speed which causes maximum impact. This rate of vibration is reduced by an increase of span length, by an increase of mass and by an increase of deflection under a given load.

In the case of short span structures not affected by cumulative vibration the same general influences prevail, excepting that the rate of vibration does not directly enter, since the critical speed is not reached.

These general principles are illustrated more or less definitely by the various results obtained. They need especially to be kept in mind in an analysis of the experimental data.

14. IMPACT UNDER CARS AND EFFECT OF FLAT WHEELS.

During the progress of the special tests the Sub-Committee on Impact made such observations as it could relative to the effect of flat spots on car wheels on the stresses in bridges. In one series of tests a car having a wheel with a very decided flat spot was purposely used, and in other tests wheels with flat spots were occasionally noted in the test trains. In one case the tires of the locomotive were badly worn and quite rough. From these observations it is impossible to report any quantitative results. A distinct effect was noticeable on such members as stringers and floor beams. This effect was similar to that produced in the case of rough track, as noted under 13.

The effect of flat spots on main truss members of a bridge was not definitely noticed in any case, but there were several cases where a train of three or four heavily loaded freight cars in a test train caused vibrations of the whole structure quite as large, relatively to the static deflection, as those caused by the locomotive. This effect was not noted in connection with any decided flat spots in the wheels, but in some cases, at least, it was caused by the vibratory motion of a car already in vibration before reaching the structure.

Several diagrams illustrating these effects are reproduced in Plate

IIj, and Table 10 is a compilation of the important data on this point. It will be noted that the speeds at which excessive truss vibrations occurred under loaded freight cars were generally quite high. The effect in many cases was so great as to be a matter of very considerable importance. No effect of any consequence was ever observed under the cars of passenger trains. The difference in equipment of freight and passenger cars in respect to smoothness of motion is very evident in the character of the diagrams produced.

15. MAXIMUM PROBABLE IMPACT AS INDICATED BY THESE TESTS.

In attempting to derive an expression which will represent maximum impact, it is necessary to distinguish between short-span structures, for which the maximum speed is less than the critical speed, and long-span structures, for which the critical speed is likely to occur. It seems reasonable to consider as a basis of conclusions the impact percentages plotted in Plates IV and IX. These diagrams represent impact percentage for plate girders and trusses based on deflections, and also those based on flange stresses and stresses in main members of trusses.

For short spans a percentage of 100 would appear to be high enough. A few results higher than this were obtained where the speeds were exceptionally high, and probably for short spans and with track in poor condition, values exceeding 100 per cent. would sometimes occur. For span lengths below 30 or 40 feet, the tests of this series are not conclusive.

For long spans, such that the maximum impact is dependent upon the critical speed, theoretical considerations indicate that the impact varies inversely with the span length. Following this suggestion from theory, a curve has been plotted on Plates IV and IX, represented by the formula $I = 60/l$, where $I =$ impact percentage and $l =$ span length. This curve is shown by the dotted line. It seems to accord fairly well with the results of the tests, but it may be considered that on Plate IX there are perhaps too many values above this line.

It is very desirable that the law of maximum impact be expressed by a single formula. Adopting as approximately correct the two expressions above mentioned for short and long spans, namely, $I = 100$ for short spans and $I = \frac{60}{l}$ for long spans, a single formula may be derived which will represent fairly well the entire range of span lengths. Such a formula is represented on the two diagrams by the full line. Its equation is

$$I = \frac{100}{1 + \frac{l^2}{20000}}$$

On the whole, this single curve fits the observations quite as well, or better than the two lines representing the different groups of span lengths. This curve is not presented here as a general impact formula, but simply as a curve which represents satisfactorily, in the judgment of the Sub-Committee, the maximum impact percentages obtained in this series of tests.

SECTION IV. SUMMARY OF RESULTS.

The following summary of results relates only to the series of tests which have been made by the Sub-Committee:

(1) With track in good condition the chief cause of impact was found to be the unbalanced drivers of the locomotive. Such inequalities of track as existed on the structures tested were of little influence on impact on girder flanges and main truss members of spans exceeding 60 to 75 feet in length.

(2) When the rate of rotation of the locomotive drivers corresponds to the rate of vibration of the loaded structure, cumulative vibration is caused, which is the principal factor in producing impact in long spans. The speed of the train which produces this cumulative vibration is called the "critical speed." A speed in excess of the critical speed, as well as a speed below the critical speed, will cause vibrations of less amplitude than those caused at or near the critical speed.

(3) The longer the span length the slower is the critical speed and therefore the maximum impact on long spans will occur at slower speeds than on short spans.

(4) For short spans, such that the critical speed is not reached by the moving train, the impact percentage tends to be constant so far as the effect of the counterbalance is concerned, but the effect of rough track and wheels becomes of greater importance for such spans.

(5) The impact as determined by extensometer measurements on flanges and chord members of trusses is somewhat greater than the percentages determined from measurements of deflection, but both values follow the same general law.

(6) The maximum impact on web members (excepting hip verticals) occurs under the same conditions which cause maximum impact on chord members, and the percentages of impact for the two classes of members are practically the same.

(7) The impact on stringers is about the same as on plate girder spans of the same length and the impact on floor beams and hip verticals is about the same as on plate girders of a span length equal to two panels.

(8) The maximum impact percentage as determined by these tests is closely given by the formula

$$I = \frac{100}{1 + \frac{l^2}{20000}}$$

in which I = impact percentage and l = span length iin feet.

(9) The effect of differences of design was most noticeable with respect to differences in the bridge floors. An elastic floor, such as furnished by long ties supported on widely spaced stringers, or a ballasted floor, gave smoother curves than were obtained with more rigid floors. The results clearly indicated a cushioning effect with respect to impact

due to open joints, rough wheels and similar causes. This cushioning effect was noticed on stringers, floor beams, hip verticals and short-span girders.

(10) The effect of design upon impact percentage for main truss members was not sufficiently marked to enable conclusions to be drawn. The impact percentage here considered refers to variations in the axial stresses in the members, and does not relate to vibrations of members themselves.

(11) The impact due to the rapid application of a load, assuming smooth track and balanced loads, is found to be, from both theoretical and experimental grounds, of no practical importance.

(12) The impact caused by balanced compound and electric locomotives was very small and the vibrations caused under the loads were not cumulative.

(13) The effect of rough and flat wheels was distinctly noticeable on floor beams, but not on truss members. Large impact was, however, caused in several cases by heavily loaded freight cars moving at high speeds.

SECTION V. RESULTS OF OTHER EXPERIMENTS.

ARTICLES UPON THE EXPERIMENTAL STUDY OF IMPACT UPON BRIDGES.

Report of the Commissioners appointed to inquire into the Application of Iron to Railway Structures. London, 1849.

This takes up the effect of intermittent loads, impacts, moving loads, etc., and contains a mass of experimental data and discussions of great value.

One set of experiments by Willis was to determine the effect of speed of trains upon the breaking strength of a girder bridge; a carriage variously loaded was passed over a pair of iron bars 9 feet long at different velocities. It was found that the deflection increased with the velocity, at least up to a certain point, and reached two or three times the static; but the bars were made as light as possible to increase the observed effect and were probably too flexible to compare with a bridge.

Ohio Railroad Report for 1881. H. Sabine, R. R. Commr. (Railroad Economics. S. W. Robinson, Van Nostrand's Engineering Magazine, 1882, Vol. xxvi, p. 392, or Van Nostrand's Science Series No. 59.)

Seven diagrams are given for the motion, both horizontal and vertical, of the center and quarter point of one span of a two-span Howe truss bridge with continuous chords over the pier. Each span was 60½ feet. The pencil was attached to a stand resting on the ground and the paper to a board fastened to the truss and perpendicular to its axis.

The impact is given at from 6 to 12 per cent. and the highest speed about 30 miles per hour.

The Frankel Extensometer. Dr. W. Fränkel. Der Civilingenieur, 1881, Vol. xxvii, p. 250.

An illustrated description of the apparatus is given and three double-page plates showing typical extensometer curves for different members of railroad bridges under live loads.

The discussion and computed results are with reference to secondary stresses, not impact, although many of the curves show the saw teeth typical of cumulative vibration.

The Deflectometer and its use alone and in connection with the Extensometer. Dr. W. Fränkel. Der Civilingenieur, 1884, Vol. xxx, p. 466.

The deflectometer is shown on a double-page plate and extensometer curves are given for different members of railroad bridges under live loads with corresponding deflection curves for the structure on two double-page plates.

Measurements of the Deformation of an Iron Rocker Pier Viaduct over the Oschützhal at Weida. Dr. W. Fränkel. Der Civilingenieur, 1887, Vol. xxiii, p. 441. Over 1,000 diagrams were obtained.

Vibration of Bridges. S. W. Robinson. Trans. Am. Soc. C. E., 1887, Vol. xvi, p. 42.

It is stated that J. T. Fanning obtained diagrams of the motion of a bridge under live load in 1875 by aid of a station near midspan supported from below. During Mr. Robinson's tours of inspection of Ohio railroads several instances were found of the determination of deflection by attaching a pencil to the bridge and marking upon a rod set on the ground below.

An indicator for recording the motion of the center of the bridge, both lateral and vertical, during the passage of a train was applied to thirteen different bridges on four different railroads and 193 diagrams were secured. The paper was moved by clock work.

Specimen diagrams are given showing cumulation vibration in a vertical plane under the engine and under the train.

For the engine, 25 of the 193 train transits, or 13 per cent., gave cumulative vibration with an average impact or increased deflection due to vibration of 18.4 per cent. and a maximum of 28.6 per cent.

For the train, 11 transits, or 6 per cent. (all freight trains), gave cumulation vibration with an average impact of 26.4 per cent. and a maximum of 50 per cent.

Formulas are derived for the time of vibration of car bodies supported by springs, and for a bridge with a uniform load of cars. For most of the train transits the panel length had a marked effect on cumulative vibration.

Tests of a Metallic Warren Girder Railroad Bridge of 35 Meters Span. M. Cüenot, Ingr. des Ponts et Chaussees. Annales des Ponts et Chaussees, 1891, Vol. ii, p. 5.

The computed and measured stresses in the different members are given. At 35 kilometers per hour, about 22 miles, the dynamic effect of the live load increased the stresses 22 per cent.

Effects of Rhythmic Shocks upon Metallic Bridges. M. Deslandres. Annales des Ponts et Chaussees, 1892, Vol. ii, p. 765.

Experiments were made upon a 30.3-meter steel truss highway bridge with various rolling loads. A few sample deflection diagrams are shown. One shows the vibration due to the passage of a single horse and cart at a trot, the former weighing 1,540 pounds and the latter 1,760, and giving a maximum deflection over half that due to the total live load capacity of 86,000 lbs. This gives a multiplication of thirteen-fold due to vibration.

Another shows the curve for three horses and carts, weighing less than 10,000 lbs. and giving approximately the same maximum deflection (0.18 inch) as the total live load, with an amplitude of vibration of 0.31 inch.

Several other curves are given to show the reduction in vibration when the impulses are a little out of time with the bridge.

A theoretical investigation is given for the time of vibration and the computed value checks the observed within about 5 per cent.

Experimental Investigations upon the Deformation of Metallic Bridges. M. Rabut, La Génie Civil, 1892, Vol. xxii, p. 88.

This work was mainly upon the deformation of riveted bridges, but a few results are given for moving loads.

For the passage of a train at low speed the same as after the passage of a train at any speed, the vibrations of the main truss have a fixed period independent of the train and of its velocity, but characteristic of the structure; the vibrations are very regular, they continue for several seconds and vanish in passing through a series of nodes and curves. During the passage of a train at high speed the total number of vibrations is independent of the speed, and depends on the relative spacing of train axles and floor beams; these vibrations correspond to the passage of the axles over the floor beams, and the amplitude increases with the velocity. The velocity has more effect upon the amplitude of the vibrations than upon the mean curve upon which they are superimposed. For long structures this amplitude is only a small part of the ordinate of the stress or deflection curve.

For usual speeds the dynamic effect on a member increases with the velocity of the train, with the freedom of the member and inversely with its mass. The excess over static is very small for the principal beams of large structures, especially in the intermediate panels; it is appreciable for the beams of small structures and for the cross-beams; and considerable for the stringers, especially near the piers.

The article also included a brief description of the instruments used for static deflection, angular deformation and stress, and for deflection and vibration under moving loads. Some of the effects of secondary stresses due to stiff joints on the direct stresses are given.

The Dynamic Effect of Moving Loads on Bridges. J. Melan. Zeit. des Oesterr. Ingenieur und Arch. Ver. 1893, p. 293. (Abstracted in Proc. Inst. of Civil Engrs. London, 1893-4. Vol. cxvii, p. 411.)

This is a mathematical treatment in which the dynamic effects are analyzed in four different classes and the effects from each expressed in terms of static stress. For a speed of 20 meters per second (about 45 miles per hour) he tabulates each as a percentage of the static and gives the sums as follows:

CHORDS.

Span	5	10	15	20	30	40	80	120 meters.
Impact	76.7	46.5	38.4	33.4	27.2	22.8	15.6	12.7 per cent.

WEB OF A LATTICED GIRDER.

Loaded portion'	5	10	15	20	30	40	80	120 meters.
Impact	66.5	42.8	34.6	30.1	26.2	23.2	17.4	14.9 per cent.

CROSS GIRDERS.

Panel length	1.5	2.0	3.0	4.0	5.0	meters.
Impact	94.0	68.0	59.0	54.0	50.0	per cent.

where the panel length equals or is less than one-tenth the span.

The Measurement of Live Load Strains in Bridges. Hankenson & Ledger, Eng. News, 1895, Vol. xxxiii, p. 300.

This article covers about 3½ pages, with a double-page diagram showing some of the typical curves. Some of the diagrams show excessive instrumental vibration. Others show the effect of cumulative vibration under the locomotive.

Bridge Deflection. M. A. Howe. Jour. Assn. of Eng. Soc., 1895, Vol. xiv, p. 513.

The apparatus used is described. The conclusions are that the vibrations produced by the engines are exceedingly small and less than those produced by the cars; and that for bridges of dimensions and types similar to those examined it did not seem necessary to add any material to the main truss members to provide for impact.

In the Railroad Gazette, 1895, Vol. xxvii, p. 339, P. H. Dudley shows the curve traced by a point of a vibrating rail upon a card moved by clock work. The observed reduction in the amplitude of vibration suggests a method of computing the rate of dissipation of the energy given to a vibrating body and hence the amplitude of the vibration due to impulses in time with the body.

Practical Methods for the Experimental Study of Metallic Bridges. M. Rabut. An. des Ponts et Chaussees, 1896, Vol. xii, p. 374.

This is a presentation of the results of five years' work in measuring deformations of metallic bridges. The first effort was to improve the types of construction and correct the usual methods of calculation, then to verify the stability of all the metallic structures on the system of l'Ouest. Illustrated descriptions are given of the instruments used. The article covers 107 pages.

In comparing a highway with a railroad bridge the following differences are brought out. In the first the live load is much smaller than the dead and it moves with small velocity; its effects proper are not very apparent and they become sensibly zero in bridges with masonry superstructure in which the static deformation is always much less than found by computation.

When the live load passes rapidly the oscillations produced are greater than the mean deflection such that the structure on its return each time passes its position of equilibrium; the curve has a very regular sinusoidal form. The period is constant and depends almost wholly on the structure, while the amplitude varies according as the period is in time with the march of the live load; they are elastic vibrations. For the railroad bridge, on the contrary, the live load is of more relative importance (for the average structure it surpasses the dead load) and it can take a very high velocity; it then impresses its character upon the deformation and the static deflection which it produces is relatively large; with the passage at high speed, save for very small structures, the bridge does not return to its position of equilibrium until the load passes off. The vibrations superimposed upon the mean deflection curve are much less than the ordinate of the curve, but sharp and irregular; they are the direct and immediate effects of the shocks which the train produces on the structure.

On the Vibrations Caused by Trains passing over Iron Bridges. C. A. Pownall and John Milne. Engineering, 1896, Vol. lxi, p. 111.

These writers made observations upon some typical Japanese railway bridges to obtain the vertical, transverse and longitudinal motions of certain bridge members when subjected to moving loads. The instrument used was a form of seismograph, giving, it is stated, for all practical purposes, absolute measurements of the movements to which it is subjected. The records were traced upon the smoked surface of an automatically rotating disc by three writing indices. Six experiments are mentioned. The first two were made upon a double-track bridge of 100 ft. span, the third upon a 40 ft. plate girder, and the other three upon a bridge of 200 ft. span. The weight of metal in the first was 70 tons, and in the last 176 tons. The locomotive used in the first two experiments weighed 38.4 tons and those used in the latter cases about 28 tons. The speed varied from 11 to 24 miles per hour. The maximum transverse motion was found to be about 0.99 inch for the 100 ft. span, 0.71 for the 40 ft. girder, and 0.79 for the 200 ft. span. The vertical displacement was small, only from 0.1 to .28 inch.

They reached the conclusion that relatively large transverse vibrations occurred because the shocks of impulses were applied nearly in synchronism with the natural period of transverse vibration of the bridge.

The vertical period was shorter and therefore the speed of the train was not great enough to produce synchronism. It would thus seem that there is a certain critical speed at which the greatest swing of a bridge takes place. This is not necessarily a high speed. They also reached the conclusion that the maximum displacement does not take place under the heaviest wheel load but depends upon the distribution of the load.

Rabut's Apparatus for Registering Deflections. Bul. Int. Ry. Congress (English Edition), 1898, Vol. xii, p. 1177.

This is an interesting article, "The Report of Tests of Ultimate Strength on a Girder Railroad Bridge of 103½ ft. Span."

Some Experiments on Bridges under moving Train Loads. F. E. Turneaure. Trans. Am. Soc. C. E., 1899, Vol. xli, p. 410.

Tests were made on twelve plate girder bridges, spans 25 to 80 ft., and on eleven truss bridges, spans 100 to 200 ft., mainly under regular railroad traffic.

A Fränkel deflectometer gave a continuous record of the deflection of the structure during the passage of the train. It was attached at or near the center. Two Fränkel-Leuner extensometers gave continuous records of the extension or compression of the portions of the members to which they were attached. It was soon found that for trusses, the lower chord, the main diagonal next the center, and the hip vertical, gave the most significant curves.

Twelve to fifteen experiments were the rule for the girder bridge and thirty to forty for the truss; giving a total of about 400 experiments with usually three curves for each.

Most of the experiments were with the trains of the regular traffic, but on two different occasions a special train was used.

The dimensions of the structures and the results of the tests are given, together with specimen curves for deflection and extension.

The effect of speed of application of the load on the mean curve (curve drawn averaging the inequalities due to vibration) was unimportant.

For speeds greater than about 25 miles per hour vibration increased the deflection or flange stress to a maximum of about 50 per cent. for spans from 25 to 55 ft. and speeds from 40 to 50 miles an hour. For spans from 60 to 85 ft. the maximum was less.

The cumulative vibration was caused by the locomotive counterweights, although a few cases were noted where it occurred under the cars; in these cases the panel length was about half a car length.

Determination of the Safe Working Stresses for Railway Bridges of Wrought-Iron and Steel. E. Herbert Stone. Trans. Am. Soc. C. E., 1899, Vol. xli, p. 467.

The author made an analysis of nearly 1,500 separate observations of bridge deflections, taken upon the railway bridges of India during the ten years, 1882-1892. These were made in various parts of India and upon all types of bridges in common use. The train speed he states may be taken at about 40 miles per hour. A curve is given showing average values of the "immediate effect" of the moving load computed on the basis of the ratio of fixed to moving load. The impact ranges from nearly 50 per cent. for the shortest spans to 4 per cent. when the moving load equals the dead load. The curve gives no information in regard to the actual range of the values obtained from the observations.

Conference upon Bridge Experimentation. By M. Rabut, Ingenieur des Ponts et Chaussees. Annales des Ponts et Chaussees, 1901, 3d Trim., p. 123.

An illustrated description of the instruments used is given and a discussion of the secondary stresses measured by them and the effect of the secondary stresses in reducing the deflection of the truss as a whole.

Typical deflection curves are given for a highway bridge and for a railroad bridge. For the former the live load is small compared with the dead, its motion across the bridge is slow and hence without sensible shock, the average position of the deflection curve changes slowly while the superimposed vibrations are isochronous and continuous, the amplitude varying with the interference of the live load impulses with the rate of vibration of the bridge.

For the latter the live load is always important and its high speed determines severe shocks which produce sharp changes of direction in the deflection curve at the instant of the shock, but without real periodicity. For the highway bridge it is the bridge which gives character to the curve, for the railroad bridge it is the train; for former it is the periodicity of the shocks, in the latter integral.

There is no danger of cumulative vibration with railroad bridges; it is a question of shocks, and among the numerous causes which can add to their importance only two are worthy of consideration; these are: first, rail joints, and second, flat spots on wheels. All other causes imaginable; movements of the connecting rods of the locomotive, amount or character of car loads, axle spacing, wheel diameter, tractive efforts, etc., etc., are of absolutely secondary importance, and the dynamics of metal bridges is summed up in two causes: rail joints and flat wheels.

In 1892 M. Rabut made a series of experiments upon a structure with a span of 4 meters (13 feet), the viaduct of Méautis near Carentan. It was necessary to choose a bridge of small dimensions in order to render more sensible the effect of shocks, which is in inverse ratio to the mass. The same locomotive was run over this bridge at speeds increasing up to 80 kilometers (50 miles) per hour.

With a rail joint of normal opening at the center of the span, the static deflection was tripled at a velocity of 80 kilometers; with the opening reduced to zero the static deflection was doubled; while with the opening increased to 2 or 3 centimeters the deflection was quintupled.

A curve is shown for the passage of a train drawn by an electric locomotive over a rail joint on the Argenteuil viaduct at a speed of 50 kilometers in which the oscillations are as great as the flexure, or in which the stress is doubled by the vibration. The curve registered was that of a cross brace.

A curve is also shown for a stringer under the cars behind the engine. The flexure is very small, but at intervals corresponding to about 3 meters, the distance between axles, a vertical line cuts the horizontal part of the curve, and represents the shock of a wheel upon the rail joint. This shows a very great increase in the stress upon the stringer.

These, with a hundred other analogous curves which have been taken, demonstrate the intensity of the effects produced by track joints.

In testing a 5-meter viaduct on the system of l'Eure a curve was obtained with almost no vibration under the locomotive, but with marked vibration under the tender; in backing over, the same thing occurred. In increasing the velocity from 3 or 4 kilometers per hour to 45 or 50 the locomotive produced nearly a constant deflection always without vibration; on the contrary the vibrations under the tender increased to such a point that the total deflection, vibration included, finally surpassed those of the locomotive which weighed twice as much as the tender. Upon examining the wheels of the tender there was found one small flat spot. We see, nevertheless, that this flat spot doubled the stress in the metal.

Upon the occasion of this unexpected discovery steps were taken to find out the effect of flat spots of wheels in track maintenance and it was discovered that several companies had brought up examples of rails broken by this cause alone. Thus, a locomotive making the journey from Paris to Limoges broke in one night 100 rails on one side of the track, and the next day in returning, 50 rails on the other side; one of the wheels had a flat spot. You can easily judge of the intensity of these shocks; it is evident that they can do much injury to metallic bridge floors.

Such are the lights thrown by experiment upon the difference between highway and railway bridges, that is to say, between structures which vibrate elastically and those which have sharp oscillations.

Under the conditions of good maintenance, according to the rules laid down, i. e., rails at least 12 meters long, rail joints reduced to one millimeter on the floor and all wheels put out of service as soon as any appreciable flat spots develop, the maximum impact at high speed will be 50 per cent. for a span of 4 meters:

20 " " 8 "
10 " " 15 "

An examination of the numerous curves taken would give approximately for maximum impact,

$$I = \frac{1}{1 + \left(\frac{L}{4}\right)^2}$$

where the span L is in meters.

Impacts, Appendix to Report of Committee XV on Iron and Steel Structures. Proc. Am. Ry. Eng. and M. W. Assn., 1905, Vol vi, p. 255.

Some two thousand tests on various members of different bridges were made with Fränkel extensometers by the Sub-Committee on Impact.

The bridges were deck plate girders of spans from 32 to 75 ft., and through pin connected trusses with stiff and verticals and end bottom chords, with stringers riveted to webs of floor beams and floor beams to posts.

The data and instruments were destroyed in the Baltimore fire, but the minimum and maximum of all tests made on the individual bridges give the impact for fast over slow speed as follows:

Plate girders 15 to 85 per cent. for span of 31½ ft.
36 to 71 per cent. for span of 60¼ ft.
18 to 61 per cent. for span of 75½ ft.

Bottom chord of trusses 16 to 57 per cent. for span of 100 ft.
11 to 32 per cent. for span of 153 ft.
18 to 50 per cent. for span of 207 ft.

Main and counter ties of trusses—
16 to 58 per cent. for span of 40 ft.
20 to 60 per cent. for span of 60 ft.
9 to 15 per cent. for span of 76½ ft.
5 to 49 per cent. for span of 114¾ ft.
4 to 15 per cent. for span of 161 ft.

Hangers 8 to 56 per cent. for span of 38 ft.
17 to 32 per cent. for span of 46 ft.

The slow speed was from 4 to 20 miles per hour and the fast speed from 40 to 70 miles.

SECTION VI. SECONDARY STRESSES OBTAINED DURING THE TESTS.

The opportunities afforded by this series of tests were availed of from time to time to get a few results relative to secondary stresses. The points which were particularly considered in this connection were the following:

(1) Unequal stress in the various eye-bars of a single member. (2) Unequal stresses on different sides of built-up chords and diagonal members. (3) Unequal stresses in vertical posts and hip verticals, due especially to the effect of the floor system. (4) Lateral bending of floor-beams near the end of a truss due to the pull of the stringers. (5) Bending stresses in eye-bars due to their own vibration.

The tests were not planned primarily to secure information on secondary stresses and the instruments were not designed with reference to such work. It has been thought desirable, however, to present a few of the more reliable and significant results as of value in showing what these secondary stresses are likely to be. In the opinion of the Sub-Committee it is very important that this phase of the work be taken up as a special study.

(1) *Unequal pull of eye-bars.*

Bridge No. 12, 176-foot pin-connected truss. Bottom chord, fourth panel.

Outside bar, stress = 2,290 lbs. per sq. in.
Inside bar, stress = 4,400 lbs. per sq. in.

Same member, instruments reversed.

Outside bar, stress = 2,380 lbs. per sq. in.
Inside bar, stress = 4,070 lbs. per sq. in.

Main diagonal.

Outside bar, stress = 3,680 lbs. per sq. in.
Inside bar, stress = 6,350 lbs. per sq. in.

(2) *Unequal stresses on different sides of built-up chords and diagonal members.*

Bridge No. 21, 64-foot span, pony truss bridge. Bottom chord (double T-section).

Inside bottom edge, stress = 4,620 lbs. per sq. in.
Inside top edge, stress = 1,680 lbs. per sq. in.
Outside bottom, stress = 7,200 lbs. per sq. in.
Outside top, stress = 4,800 lbs. per sq. in.

Bridge No. 26, 124-foot span riveted truss. Main diagonal.

Inside top edge, stress = 4,340 lbs. per sq. in.
Outside bottom, stress = 3,430 lbs. per sq. in.

(3) *Unequal stresses in posts and hip verticals.*

Bridge No. 17, 160-foot span, pin-connected truss. Second vertical post.

Inside edge, stress = 1,900 lbs. per sq. in. compression.
Outside edge, stress = 3,050 lbs. per sq. in. compression.

Same member, same test, with load further advanced.

Inside edge, stress = 2,380 lbs. per sq. in. tension
Outside edge, stress = 1,460 lbs. per sq. in. compression.

Bridge No. 26, 300-foot span, pin-connected truss. Sixth vertical post.

Inside north corner, stress = 3,560 lbs. per sq. in. tension.
Outside south corner, stress = zero.

Bridge No. 23, 124-foot riveted truss. Hip vertical.

Inside west corner, stress = 3,470 lbs. per sq. in. tension.
Inside east corner, stress = 3,080 lbs. per sq. in. tension.
Outside west corner, stress = 1,920 lbs. per sq. in. tension.

Bridge No. 37, 206-foot span riveted truss. Hip vertical.

Inside east corner, stress = 4,830 lbs. per sq. in. tension.
Inside west, stress = 3,000 lbs. per sq. in. tension.
Outside east, stress = 1,320 lbs. per sq. in. tension.
Outside west, stress = 840 lbs. per sq. in. tension.

Same member.

Inside east, stress = 4,190 lbs. per sq. in. tension.
Inside west, stress = 2,640 lbs. per sq. in. tension.
Outside east, stress = 1,710 lbs. per sq. in. tension.
Outside west, stress = zero.

(4) *Lateral bending in floor beams.*

Bridge No. 16, 228-foot pin-connected truss. West end floor beam, west end of span loaded.

East lower flange, stress = 2,070 lbs. per sq. in. tension.
West lower flange, stress = zero.

Same beam, bridge fully loaded, cars on floor beam.

West flange, stress = 3,000 lbs. per sq. in. compression.
East flange, stress = 3,940 lbs. per sq. in. tension.

Bridge No. 28, 124-foot riveted truss. South end floor beam, train headed south.

South flange, stress = 2,300 lbs. per sq. in. compression.
North flange, stress = 2,880 lbs. per sq. in. tension.

(5) *Stresses due to vibration of member.*

Some of the most excessive of the vibrations are illustrated on Plate IId. Diagram 912 is a record obtained on a long diagonal eyebar. In this case the maximum axial stress was about 3,000 lbs. per sq. in. The axial stress at time of maximum vibration was practically zero. The maximum fiber stress due to this vibration was about 3,500 lbs. per sq. in.

Many other tests showed large vibrations of individual members, frequently producing stresses as great as 1,000 to 1,500 lbs. per sq. in. on extreme fiber in addition to the axial stress.

SECTION VII. THEORETICAL ANALYSIS.

1. TIME OF VIBRATION OF A UNIFORMLY LOADED BEAM OR TRUSS.

Fig. 4 represents such a beam.

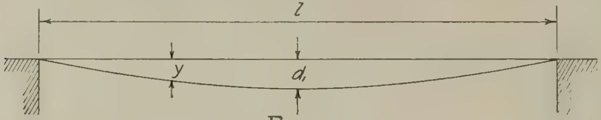


FIG 4.

Let w = dead load per foot, assumed as uniform;

p = live load per foot, assumed as uniform;

d_1 = center deflection in feet due to load p, as determined by measurement.

T = period of vibration under load w.

In applying the load p to the bridge the total work done in deflection is

$$W=\int_0^l \frac{p\,dx}{2}\,y=\frac{1}{2}\,p\int_0^l y\,dx \ldots\ldots (1)$$

After deflection has occurred and a static condition reached, imagine the live load to be suddenly lifted from the bridge. The bridge will then spring up and start vibrating. At the center of its path all energy is kinetic and must be equal in amount to the potential energy, or work W given above.

Let v = velocity of any point of the beam at its central position, then the total kinetic energy it

$$K.\,E.=\int_0^l \frac{1}{2}\,\frac{w}{g}\,v^2\,dx=\frac{1}{2}\,\frac{w}{g}\int_0^l v^2\,dx \ldots\ldots (2)$$

But for a simple harmonic motion $v=\dfrac{2\,\pi\,y}{T}$, hence from (2) we have

$$K.\,E.=\frac{w}{g}\cdot\frac{2\,\pi^2}{T^2}\int_0^l y^2\,dx \ldots\ldots (3)$$

Equating (1) and (3) and reducing we get

$$T^2=\frac{4\pi^2}{g}\cdot\frac{w\int_0^l y^2\,dx}{p\int_0^l y\,dx} \ldots\ldots (4)$$

Assuming a curvature during vibration to be similar to the static curve of a uniformly loaded beam the expression $\dfrac{\int_0^l y^2\,dx}{\int_0^l y\,dx}$ is found to be closely equal to $0.8d_1$, whence

$$T^2=\frac{4\pi^2}{g}\;\frac{w}{p}\times(.8d_1) \text{ or, very nearly}$$

$$T^2=\frac{w}{p},\ d_1 \text{ (in foot sec. units)} \ldots\ldots (5)$$

Under a load $w+p$ the period of vibration will be

$$T_{w+p}=\sqrt{\frac{w+p}{p}\times d_1} \ldots\ldots (6)$$

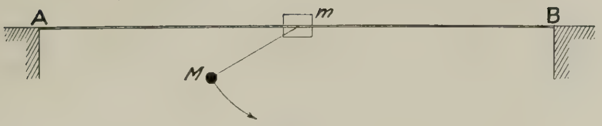


FIG. 5.

VIBRATION OF A BEAM DUE TO THE ACTION OF A REVOLVING WEIGHT PLACED ON A BEAM AND ROTATING AT A UNIFORM VELOCITY.

In this case all the mass of the beam is assumed to be concentrated at the center.

Let $m =$ mass at center;
$M =$ mass of rotating body;
$r =$ length of arm of M;
$R = \frac{M}{m}$. This is relatively quite small.
$T =$ vibration period of the beam alone;
$f =$ frequency of vibration for beam $= \frac{1}{T}$;
$f_1 =$ frequency of rotation of M;
$\omega =$ angular velocity $= 2\pi f$
$t =$ time elapsing from initial condition;
$k =$ force required at the center to deflect the beam a unit distance.

In the same manner as Eq. (4) was derived we readily get the relation

$T^2 = \frac{4\pi^2 m}{k}$ whence $k = \frac{4\pi^2 m}{T^2} = 4\pi^2 m f^2$.

It is assumed that at the beginning the beam AB is unstrained and the mass m is at rest (gravity action will not be considered); the body M is at the same level as m and on the left but that it is already in motion at the given rate. As it moves it now begins to exert a downward force upon m due to the vertical component of centrifugal force. It then continues to rotate and this produces motion of the mass m The analysis of this motion is as follows (FIG. 6):

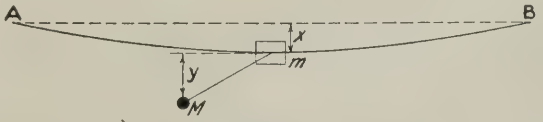


FIG. 6.

The equation of force and acceleration of the system is

$$-M\frac{d^2y}{dt^2}=(m+M)\frac{d^2x}{dt^2}+kx \quad \ldots\ldots (7)$$

in which k is the upward force exerted by the beam upon m and is proportional to x. Noting that $\frac{d^2y}{dt^2}=r\omega^2 \sin \omega t$, we have from (7)

$$\frac{d^2x}{dt^2}+\frac{k}{m+M}x=\frac{Mr\omega^2}{m+M}\sin \omega t \quad \ldots\ldots (8)$$

Equation (8) integrates and reduces to

$$x=\frac{-rR}{\frac{f^2}{f_1^2}-(1+R)}\left[\sin 2\pi f_1 t-\frac{f_1}{f}\sqrt{1+R}\cdot\sin\left(\frac{1}{\sqrt{1+R}}2\pi f t\right)\right] \quad (9)$$

in which R is substituted for $\frac{M}{m}$ and $4\pi^2 m f^2$ for k. Equation (9) is general and will give the position of m at any time t.

For cumulative vibration the frequencies f and f_1 are equal. Placing these equal in Eq. (9) and considering that R is a small quantity, we have approximately for such a case,

$$x=r\frac{R}{2}(\sin 2\pi f_1 t-2\pi f_1 t\cos 2\pi f_1 t) \quad \ldots\ldots (10)$$

The angle $2\pi f_2 t$ is the total angular movement of M in time t. Call this angle θ, then

$$x=r\frac{R}{2}(\sin\theta-\theta\cos\theta) \quad \ldots\ldots (11)$$

The value of x then varies with time in accordance with the function $\sin\theta-\theta\cos\theta$, whose maximum values occur for $\theta=\pi$, 2π, 3π, etc., and are equal to π, -2π, $+3\pi$, -4π, etc. Fig. 7 is a plot of this curve.

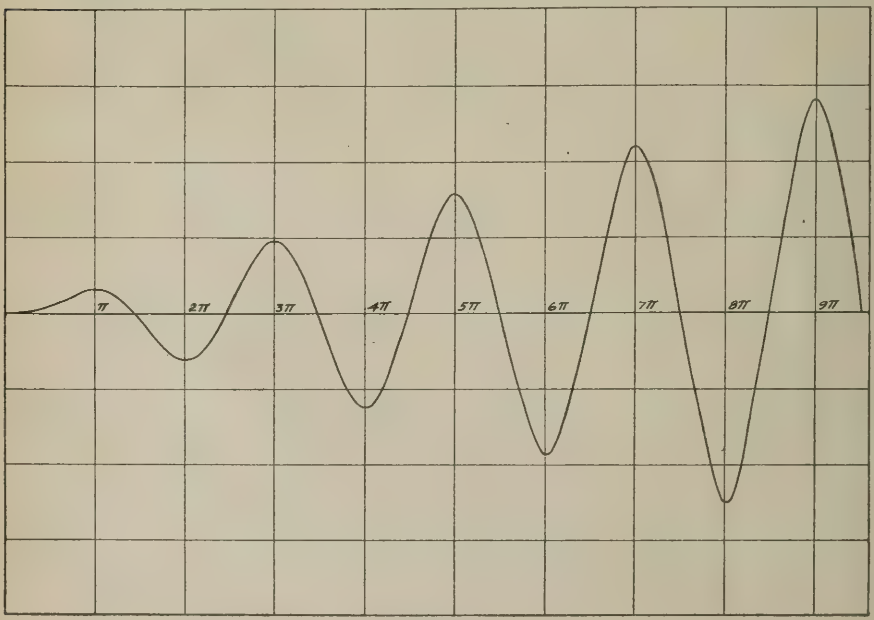


Fig 7.

SECTION VIII.

CONTRIBUTORS TO THE IMPACT TEST FUND—1907.

Atchison, Topeka & Santa Fe Railway	$200.00
Atlantic, Quebec & Western	2.00
Baltimore & Ohio Railroad	150.00
Bessemer & Lake Erie Railroad	5.85
Boston & Maine Railroad	100.00
Canadian Pacific Railway	200.00
Central Railroad of New Jersey	25.00
Chicago & Alton Railway	29.10
Chicago, Burlington & Quincy Railroad	500.00
Chicago & Eastern Illinois	24.51
Chicago, Indiana & Southern Railroad	12.48
Chicago Junction Railway	100.00
Chicago, Milwaukee & St. Paul Railway	500.00
Chicago, Rock Island & Pacific Railway	200.00
Chicago, St. Paul, Minneapolis & Omaha Railway	30.00
Chicago Terminal Transfer Railroad	10.00
Chicago & Western Indiana Railroad	10.00
Cincinnati, Hamilton & Dayton Railroad	20.00
Cincinnati, New Orleans & Texas Pacific Railroad	18.90
Cincinnati Northern Railroad	6.18
Cleveland, Cincinnati, Chicago & St. Louis Railway	66.00
Delaware, Lackawanna & Western Railroad	100.00
Elgin, Joliet & Eastern Railroad	4.20
El Paso & Southwestern System	24.23
Erie Railroad	64.50
Fonda, Johnstown & Gloversville Railroad	2.31
Grand Trunk Railway System	115.93
Great Northern Railway	180.00
Guantanamo Railroad (Cuba)	5.00
Harriman Lines	342.63
Hocking Valley Railway	25.00
Illinois Central Railroad	111.66
Kansas City, Mexico & Orient Railway	8.10
Lake Shore & Michigan Southern Railway	100.00
Lehigh Valley Railroad	50.00
Long Island Railroad	12.00
Louisiana & Arkansas Railroad	4.33
Louisville & Nashville Railroad	124.23
Manila Railroad (Philippine Islands)	6.00
Michigan Central Railroad	65.00
Minneapolis & St. Louis Railroad	55.28
Minneapolis, St. Paul & Sault Ste. Marie	68.43
Mississippi River & Bonne Terre Railroad	10.00
Missouri, Kansas & Texas Railway	92.16
Missouri Pacific Railway	200.00
Nashville, Chattanooga & St. Louis Railway	50.00
National Railway of Tehuantepec	6.30
New Orleans & Northeastern Railroad	15.33
New York Central & Hudson River Railroad	200.00
New York, Chicago & St. Louis Railroad	20.00
New York, Ontario & Western Railway	14.82

Norfolk & Southern Railway	13.77
Norfolk & Western Railway	50.00
Northern Pacific Railway	116.00
Philadelphia & Reading Railway	25.00
Pittsburg & Lake Erie Railroad	100.00
Rio Grande, Sierra Madre & Pacific	10.00
San Antonio & Aransas Pass Railroad	30.00
San Pedro, Los Angeles & Salt Lake Railroad	27.93
St. Louis & San Francisco Railroad	100.00
South & Western Railway	4.08
Southern Railway	200.00
Temiskaming & Northern Ontario Railway	5.00
Terminal Railroad Association of St. Louis	10.00
Texas Midland Railroad	7.50
Virginian Railway	10.00
Wisconsin Central Railroad	30.00
American Bridge Company	500.00
Dominion Bridge Company	25.00
E. E. Hart	10.00
A. J. Himes	10.00
A. W. Johnston	10.00
W. B. Poland	50.00
Total for 1907	$5,631.74

CONTRIBUTORS TO THE IMPACT TEST FUND—1909.

Algoma Central Railway	$ 2.80
Atchison, Topeka & Santa Fe Railway	200.00
Atlanta, Birmingham & Atlantic Railroad	15.00
Baltimore & Ohio Railroad	150.00
Bessemer & Lake Erie Railroad	5.85
Boston & Maine Railroad	100.00
Canadian Pacific Railway	200.00
Carolina, Clinchfield & Ohio Railway	7.50
Central of Georgia Railway	38.00
Central Railroad of New Jersey	25.00
Chicago & Alton Railway	29.10
Chicago & Eastern Illinois Railroad	24.51
Chicago, Indiana & Southern Railroad	12.00
Chicago, Rock Island & Pacific Railway	200.00
Chicago Terminal Transfer Railroad	10.00
Chicago & Western Indiana Railroad	10.00
Chihuahua & Pacific Railway	15.28
Cincinnati, Hamilton & Dayton Railroad	20.00
Cincinnati, New Orleans & Texas Pacific Railroad	18.90
Cleveland, Cincinnati, Chicago & St. Louis Railway	66.00
Colorado & Southern Railway	50.00
Delaware & Hudson Company	25.00
Delaware, Lackawanna & Western Railroad	100.00
Denver & Rio Grande Railroad	100.00
Duluth & Iron Range Railroad	5.04
Elgin, Joliet & Eastern Railroad	4.00
El Paso & Southwestern System	24.23
Erie Railroad	64.50
Fort Smith & Western Railway	3.00
Grand Trunk Railway System	116.13

Great Northern Railway	180.00
Harriman Lines	342.63
Hocking Valley Railway	25.00
Illinois Central Railroad	111.66
Kansas City, Mexico & Orient Railway	8.10
Lake Shore & Michigan Southern Railway	100.00
Lehigh Valley Railroad	50.00
Long Island Railroad	12.00
Louisiana & Arkansas Railroad	4.33
Louisville & Nashville Railroad	124.23
Michigan Central Railroad	65.00
Mississippi River & Bonne Terre Railroad	10.00
Missouri, Kansas & Texas Railway	92.16
Nashville, Chattanooga & St. Louis Railway	50.00
National Railway of Tehuantepec	6.30
New Orleans & Northeastern Railroad	15.33
New York Central & Hudson River Railroad	200.00
New York, Chicago & St. Louis Railroad	20.00
New York, Ontario & Western Railway	14.82
Norfolk & Southern Railway	13.77
Norfolk & Western Railway	50.00
Northern Pacific Railway	116.00
Pennsylvania Lines West of Pittsburg	200.00
Pennsylvania Railroad	250.00
Peoria & Pekin Union Railroad	10.00
Philadelphia & Reading Railway	25.00
St. Louis & San Francisco Railroad	100.00
St. Louis Southwestern Railroad	50.00
San Antonio & Aransas Pass Railroad	30.00
San Pedro, Los Angeles & Salt Lake Railroad	27.93
Seaboard Air Line	25.00
Southern Railway	125.00
Terminal Railroad Association of St. Louis	10.00
Texas Midland Railroad	15.00
Wabash Railroad	50.00
Dominion Bridge Company	25.00
Total for 1909	$4,206.10

RECAPITULATION.

Amount contributed in 1907	$5,631.74
Amount contributed in 1909	4,206.10
Total amount collected	$9,837.84

TABLE I.

CALIBRATION TABLE

INSTRUMENT NUMBER	LEVER MULTIPLICATION	VALUE OF 1" ORDINATE E=30000000 L=48"	SPEED OF PAPER IN. PER SEC.
DEFLECTION	2		
1	51.0	12200	0.64
2	50.5	12400	
3	45.7	13700	0.54
4	49.1	12700	0.61
5	52.2	12000	0.52
6	54.3	11500	0.70
7	51.1	12200	0.58
8	52.6	11900	0.60
9	47.0	13300	0.50
10	47.2	13200	0.39
11	52.5	11900	0.45
12	48.5	12900	0.56

Date 1907	Rail Road	Location of Bridge	Kind of Bridge	Span Length	Number of Bridge	Engine Number	Record Numbers	Data Sheet Number	Summary Sheet Number
AUGUST 28	ILLINOIS CENTRAL	CEDAR RAPIDS IA.	PIN CONNECTED	148'-6"	1	1013	1-14	1	1
"		"	"	"	1	904	15-24	2	
AUGUST 29		WEBSTER CITY IA.	"	156'-9"	2	1018	25-49	3	
"		"	"	135'-11"	3	1018	40-49	4	2
AUGUST 30		"	"	"	4	47	50-74	5	
"		"	"	156'-9"	2	47	68-74	6	
AUGUST 31		WALL LAKE IA.	"	111'-11¾"	5	20	75-91	7	3
SEPT. 2		GRABLE IA.	"	126'-8"	6	34	92-120	8	
"		"	THRU PLATE GIRDER	45'-0"	7	34	92-120	9	
SEPT. 3		"	"	"	7	234	121-145	10	4
"		"	PIN CONNECTED	126'-8"	8	234	121-145	11	
SEPT. 4	C. B. & Q. R. R.	APPLE RIVER	"	132'-0"	9	1919	146-165	12	
SEPT. 5		"	"	"	9	1921	166-207	13	5
SEPT. 6		"	"	"	9	2527	208-234	14	
SEPT. 7		"	"	"	9	2523	235-264	15	6
SEPT. 9		"	"	"	9	1919	265-301	16	
SEPT. 10		LA GRANGE ILL.	DECK PLATE GIRDER	30'-0"	10	2123	302-324	17	6
"		"	THRU " "	63'-0"	11	2123	302-324	18	7
SEPT. 11		"	DECK " "	30'-0"	10	2123	325-360	19	6
"		"	THRU " "	63'-0"	11	2123	325-360	20	7
SEPT. 12	C. M. & St. P.	BYRON ILL.	PIN CONNECTED	176'-6"	12	1703	361-392	21	8
"		DAVIS JUNC. ILL.	DECK-BALLASTED FLOOR PLATE GIRDER	80'-0"	13	1703	393-404	22	
SEPT. 13		BYRON ILL.	PIN CONNECTED	176'-6"	12	304	405-425	23	9
"		DAVIS JUNC ILL.	DECK-BALLASTED FLOOR PLATE GIRDER	80'-0"	13	304	426-435	24	
SEPT. 14		BYRON ILL.	PIN CONNECTED	176'-6"	12	925	436-462	25	10
SEPT. 16	C.R.I. & P.	METZ IA.	"	152'-6"	14	1672	463-487	26	
"		"	DECK PLATE GIRDER	44'-0"	15	1672	477-487	27	
SEPT. 17		"	PIN CONNECTED	152'-6"	14	819	488-525	28	11
"		"	DECK PLATE GIRDER	44'-0"	15	819	494-525	29	
SEPT. 19	NICKLE PLATE	FT. WAYNE IND.	PIN CONNECTED	228'-0"	16	147	526-555	30	12
SEPT. 20		"	"	"	16	185	556-570	31	13
"		"	"	"	16	181	571-586	32	

TABLE 2—b.

1908

GENERAL TABLE

DATE	R.R.	LOCATION OF BRIDGE	R.R. BRIDGE NO.	KIND AND DESCRIPTION OF BRIDGE	SPAN LENGTH	NUMBER OF TRACKS	NUMBER OF BRIDGE TESTED	ENGINE NUMBERS	RECORD NUMBERS
7-14-15	C. M. & ST. P.	BYRON ILL.	2312	SKEW-THRU-RIVETED-OPEN FLOOR	159'-9"	1	17	263-939	600-649
7-16		DAVIS JUNCT. ILL.	2284	DECK-BALLASTED FLOOR PL. GIRD.	80'-0"	2	13	939	650-664
"		"	"	" " " " "	80'-0"	2	18	939	
7-18		BARDWELL WIS.	A 496	OPEN DECK - PLATE GIRDER	65'-5"	1	19	263	665-676
7-20		AVALON WIS.	A 500	DECK-CONCRETE SLAB-BALLASTED FLOOR-PLATE GIRDER	70'-0"	1	20	263	677-702
7-21-22		MILBERN ILL.	191	PONY RIVETED WARREN TRUSS-BAL. FLOOR	64'-0"	2(3 TRUSSES)	21	573-1403	703-756
"		"	"	THRU PL. GIRD. BALLASTED FR.	92'-6"	2(3 GIRDS)	22	573-1403	
7-23-25	SANTA FE	CARROLTON MO.	563	RIVETED THRU-BAL'STD FLOOR	124'-0"	2	23	1822-1115	757-782 813-837
7-24-27		HARDIN MO.	573	PIN-CON. THRU-BAL'STD FLOOR	149'-0"	2	24	1824-542 1115	783-812
"		"	"	DECK PL. GIRD-BAL'STD FLOOR	70'-0"	2	25	1824-542 1115	838-860
7-29-30		PURCELL OKLA.	140	CURVED TOP CHORD-PIN-CON. THRU OPEN FLOOR	300'-0"	1	26	1435-1066	861-910
7-31 8-1		"	"	" " " "	210'-0"	1	27	1434-1066	911-959
8-3-4	R.I.	ZYBA KAS.	3034	RIVETED THRU WARREN OPEN DECK	124'-0"	1	28	1746	960-1026
"		"	"	OPEN DECK - PLATE GIRDER	50'-0"	1	29	1746	
8-5		ALMA KAS	93	OPEN FLOOR-THRU PL. GIRD	100'-0"	1	30	2200	1027-1051
8-6		McFARLAND KAS.	88	" " " " "	60'-0"	1	31	2200	1052-1079
8-10-11	NORFOLK & WESTERN	SCIOTOVILLE O.	1059	SKEW-THRU-PIN-CON. OPEN FLOOR	152'-0"	1	32	1059-594 1033	1080-1112
"		"	"	OPEN FLOOR DECK PL. GIRD	43'-0"	1	33	1059-594 1033	
8-12-13		WAVERLY O.	1104	THRU-PIN-CON. OPEN FLOOR	152'-0"	1	34	1059-603	1113-1183
"		"	"	OPEN FLOOR DECK VIADUCT PLATE GIRDER	48'-0"	1	35	1059-603	
8-14-15		OMEGA O.	1108	SKEW-THRU-RIVETED WARREN-OPEN FLOOR	126'-0"	2	36	603-494	1184-1241
8-17-18	PENNA LINES WEST	NILES O.	2	OPEN FLOOR-RIVETED CURVED TOP CHORD	206'-0"	2	37	7204-7027	1242-1296
8-19		WOOSTER O.	120	SKEW-BAL.-THRU PLATE GIRD.	47'-10½"	4(5 GIRDS)	38 OUTS. 39 INS.	7204-7027	1297-1336
8-20-21		WINONA LAKE IND.	332B	" " " " "	59'-2"	2(3 GIRDS)	40	7204-7027	1337-1390
8-21-22-25		PLYMOUTH IND.	366B	" " " " "	37'-0"	2(2 GIRDS)	41	7204-7027 7451	1391-1423 1489-1512
8-22-24		"	366	OPEN FLOOR RIV. PONY TRUSS	104'-0"	2(2 GIRDS)	42	7204-7027 7451	1424-1460 1482-1488
"		"	366A	THRU-BAL. FLOOR-PL. GIRD.	49'-0"	2(2 GIRDS)	43	7204-7027 7451	1461-1481
8-26-27-28	C.B.&Q.	APPLE RIVER ILL	152-93	THRU-OPEN FLOOR-PIN-CONN.	132'-0"	1	9	2703-2527	1513-1629
10-27-28-29	N.Y.C.	SCHENECTADY N.Y.		DECK PLATE GIRDER	55'-0"	1	44	(3235-18) ELEC 3883	1700-1749
1909 -15-16	C.B.Q.	BELLEFONTAINE MO		D.T. THRU BALTIMORE TRUSS	440'-0"	2	45	2543	1800-1835

1907 BRIDGE TABLE.

DATE 1907.	RAIL ROAD	LOCATION OF BRIDGE	RAILROAD BRIDGE NUMBER	KIND AND DESCRIPTION OF BRIDGE	SPAN LENGTH	NUMBER OF TRACKS	NUMBER OF BRIDGE TESTED	WEIGHTS OF BRIDGE			REMARKS
								TOTAL STEEL	TOTAL TRACK TIES. BALLAST ETC.	TOTAL	
8-28	ILLINOIS CENTRAL	CEDAR FALLS IA.	282.65	THRU. PIN-CONNECTED, OPEN FL'R	148'-6"	1	1	325,218	59400	384600	Floor Estimated 400#/lin ft.
8-29.30		WEBSTER CITY. IA.	W 354.76	do	156'-9"	1	2	235,179	62700	297900	" " "
8-29		do.	do	do	135'-11"	1	3	214,296	54368	268650	" " "
8-30		do.	do.	do	do.	1	4	do	54368	268650	" " "
8-31		WALL LAKE. IA.	WA. 422.68	THRU PIN-CONNECTED. SKEW. SHALLOW I BEAM FL'R	111'-11¾"	1	5	383266	19580	402850	" " 175#/lin ft.
9-2,3.		GRABLE IA.	WA. 500.34	THRU. PIN CONNECTED. OPEN FLOOR	126'-8'	1	6	273 721	50666	324400	" " 400#/lin ft.
9-2.3		do.	do.	THRU. OPEN FLOOR. PLATE GIRDER	45'-0"	1	7	58,096	18000	76100	" " "
9-3		do.	do.	THRU. PIN-CONNECTED. OPEN FLOOR	126'-8"	1	8	273 721	50666	324400	" " "
9-4 to 9-9	C. B. & Q.	APPLE RIVER, Ill.	152.93	THRU. PIN-CONNECTED. OPEN FLOOR	132'-0"	1	9	196 449	52800	249250	" " "
9-10, 11.		LA GRANGE. Ill.	13 B	DECK PLATE GIRDER OPEN FLOOR.	30'-0"	1	10				
9-10, 11		do.	do.	THRU. SKEW. OPEN FLOOR PLATE GIR	63'-0"	2	11				4 GIRDERS.
9-12, 13, 14	C. M. & ST. P.	BYRON, Ill.	2312	THRU. SKEW. PIN-CONNECTED. OPEN FLOOR	176'-6"	1	12				
9-12, 13		DAVIS Jct. Ill.	2284	DECK BALLASTED FLOOR. PLATE GIRDER	80'-0"	1	13	100 000	140 000	240 000	
9-16, 17	ROCK ISLAND	METZ, IA.	302½	THRU. RIVETED. OPEN FLOOR.	152'-6"	1	14	285 656	47 125	332 790	
9-16, 17		do.	303	DECK. OPEN FLOOR. PLATE GIRDER.	44'-0"	1	15				
9-19, 20	NICKEL PLATE	Ft. WAYNE, IND.		THRU. CURVED TOP CHORD. OPEN FLOOR	228'-0"	1	16	426 720	91200	517900	Floor Estimated - 400#/lin. ft.

1908 BRIDGE TABLE

Date 1908	Rail Road	Location of Bridge		Railroad Bridge Number	Kind and Description of Bridge	Span Length	Number of Tracks	Number of Bridge Tested	Weights of Bridge			Remarks.
									Total Steel	Total Track, Ties, Ballast etc.	Total	
7-14-15	C.M. & St.P.	Byron	Ill.	Z 312	Skew- Thru-Riveted-Open Floor	159'-9"	1	17	364000	63900	427900	
7-16		Davis Junction	Ill.	Z 284	Deck-Ballasted Floor-Plate Girder.	80'-0"	2	18	100000	140000	240000	
"		"		"	" " " " "	80'-0"	2	18	125000	114400	239400	
7-18		Bardwell	Wis.	A496	Open-Deck - Plate Girder	65'-5"	1	19	58700	26000	84700	
7-20		Avalon	Wis.	A 500	Deck-Concrete Slab Ballasted Floor- Plate Girder.	70'-0"	1	20	76400	245000	321400	
7-21-22	Santa Fe	Milbern	Ill.	191	Pony Riveted Warren Truss Ballasted Floor-3 Trusses	64'-0"	2(3 Trusses)	21	108200	97400	205600	Weights for 1 outside truss, center truss & floor for 1 track
"		"		"	3 Girders Thru-Plate Girder-Ballasted Floor	92'-6"	2(3 Girders)	22	275000	141250	416250	Weights for 1 outside girder, center girder & floor for 1 track.
7-23-25		Carrollton	Mo.	563	Shallow Suspended Riveted Thru - Ballasted Floor	124'-0"	2	23	641720	426060	1067780	
7-24-27		Hardin	Mo.	573	Pin Connected Thru Shallow Suspended Ballasted Floor	149'-0"	2	24	771767	533420	1305187	
"		"		"	Deck Plate Girder Ballasted Floor	70'-0"	2	25	81430	135660	217090	Weights for 2 girders for 1 track
7-29-30		Purcell	Okla.	140	Curved Top Chord-Pin Connected Thru- Open Floor.	300'-0"	1	26	992438	120000	1,112,438	Floor Estimated
7-31-8-1		"		"	" " " "	210'-0"	1	27	483582	84000	567582	Floor Estimated
8-3-4	Rock Island	Zyba	Kas.	3034	Riveted Thru-Warren- Open-Deck	124'-0"	1	28	203800	44640	248440	
"		"		"	Open-Deck- Plate Girder	50'-0"	1	29	36900	18000	54900	
8-5		Alma	Kas.	93	Open Floor- Thru-Plate Girder	100'-0"	1	30	165200	36000	201200	
8-6		Mc.Farland	Kas.	88	" " "	60'-0"	1	31	71900	21600	93500	
8-10-11	Norfolk & Western	Sciotoville	Ohio	1059	Skew-Thru-Pin Connected Open Floor Suspended Floor Beams- 3 Stringers	152'-0"	1	32	223000	61000	284000	
"		"		"	Open Floor Deck Plate Girder	43'-0"	1	33				
8-12-13		Waverly	Ohio	1104	Suspended Floor Beams - 3 Stringers Thru- Pin Connected - Open Floor	152'-10"	1	34	223000	61000	284000	
"		"		"	Open Floor Deck Viaduct Plate Girder	48'-0"	1	35	34750	19200	53950	Floor Estimated
8-14-15		Omega	Ohio	1108	Skew Thru Riveted Warren Open Floor	126'-0"	2	36	471800	50400	522000	Floor Estimated - 1 Track
8-17-18		Niles	Ohio	2	Thru-Riveted-Open Floor-Curved Top Chord 4 Stringers for each track	206'-0"	2	37	1171901	124000	1295900	
8-19	Penna. Lines West.	Wooster	Ohio	120	4 Track-Thru-Ballasted Floor- Box Floor Construction- Plate Girders	77'-10½"	4(5 Girders)	38 Outside 39 Inside	555310	1,268,686	1824000	Weights for 5 girders & trough floor
8-20-21		Winona Lake	Ind.	332B	Skew- Thru-Ballasted Floor- Box Floor Construction- Plate Girders	59'-2"	2(3 Girders)	40	194853	360080	554950	Weights for 3 girders & trough floor
8-21-22-25		Plymouth	Ind.	366B	" " "	37'-0"	2(2 Girders)	41	167183	178126	345300	
8-22-24		"		366	Pony Riveted Open Floor Warren Truss	104'-0"	2(2 Girders)	42	440044	64000	504050	
"		"		366A	Thru Ballasted Floor Box Floor Construction Plate Girders	49'-0"	2(2 Girders)	43	250286	230446	480750	
8-26-27-28	C.B.&Q.	Apple River	Ill.	152.93	Thru-Open Floor - Pin Connected.	132'-0"	1	9	196449	52800	249250	Floor Estimated
10-27-28-29	N.Y.C.	Schenectady.	N.Y.	391	Deck-Open Floor Plate Girder	53'-10"	1	44				
8-15-16, 1909	C.B&Q	Bellefontaine,	Mo.	—	Thru. Pin Con. Open Floor, Baltimore	440'-0"	2	45	2,720,000	396000	3,116000	Floor Estimated

LOCOMOTIVE TABLE 1907

ROAD	ENGINE		WEIGHT ON DRIVING AXLE	TOTAL WEIGHT		DRIVERS			STROKE	WT. OF OVERBALANCE AT CRANK PIN CENTER	
	NUMBER	CLASS		ENGINE ONLY	ENGINE & TENDER	NUMBER	DIAMETER	CIRCUM.		TOTAL	WT. PER WHEEL
ILLINOIS CENTRAL	1013		51000	188000	335600	2	79"	20.7'	28"	797	399
	904		45250	203500	348500	4	63"	16.5'	30"	919	230
	1018		51000	188000	335600	2	79"	20.7'	28"	797	399
	47		40750	157200	259200	3	63"	16.5'	28"		
	20		40750	157200	259200	3	63"	16.5'	28"		
	34		40750	157200	259200	3	63"	16.5'	28"		
	234		38930	149700	251700	3	69"	18.1'	26"	567	189
C. B. & Q. R.R.	1919	R4	52300	210000	358200	3	69"	18.1'	28"	756	252
	1921	R4	52300	210000	358200	3	69"	18.1'	28"		
	2527	P2	46500	187000	307400	2	84¼"	22.1'	26"	694	347
	2523	P2	46500	187000	307400	2	84¼"	22.1'	26"	694	347
	2123	R5	48600	216000	364200	3	69"	18.1'	28"		
C. M. & St. P.	1703	B4	44300	178900	303900	3	62"	16.25'	28"	1352	451
	304	B3	41330	166800	283600	3	68"	17.8'	26"	782	261
	925	A2	46225	177500	303100	2	84¼"	22.1'	28"	1632	816
R. I.	1672	C39	48800	206000	346000	4	63"	16.5'	30"	908	227
	819	N28	46000	193000	335000	3	69"	18.1'	26"	762	254
NICKEL PLATE	147	N1	35500	160000	280000	4	62"	16.25'	28"	692	173
	185	R	39000	159000	300000	3	72"	18.85'	26"	366	122
	181	O	40300	123700	234700	2	68"	17.8'	24"	486	243

TABLE 4—b.

1908	LOCOMOTIVE TABLE											
ROAD	ENGINE			WEIGHTS		WEIGHT ON MAIN DRIVING AXLE	DRIVERS			STROKE	WT OF OVERBALANCE AT CRANK PIN CENTER	
	NUMBER	CLASS	KIND	ENGINE+TENDER	ENGINE ONLY		NO.	DIAM.	CIRCUM.		TOTAL	WT/WHEEL
C.M.&ST.P.	263	4-6-0	SIMPLE	302600	177000	45300	3	69"	18.09'	30"	786	262
	939	4-4-2	COMP.	303070	177470	46225	2	84¼"	22.10'	28"	1632	816
SANTA FE	573	2-6-0	COMP.	264000	164000	44010	3	63"	16.52'	28"	1233	411
	1403	4-4-2	B.C.	366000	201500	49600	2	79"	20.70'	26"		
	1822	2-6-2	B.C.	423200	248200	57700	3	69"	18.09'	28"		
	1824	2-6-2	B.C.	423200	248200	57700	3	69"	18.09'	28"		
	1115	2-6-2	COMP.	322800	210190	50180	3	69"	18.09'	28"	1205	402
	542	4-4-2	B.C.	366000	201500	49600	2	73"	19.13'	26"		
	1435	4-4-2	B.C.	368600	204100	56850	2	79"	20.70'	26"		
	1434	4-4-2	B.C.	368600	204100	56850	2	79"	20.70'	26"		
	1066	2-6-2	COMP.	322800	210190	50180	3	69"	18.09'	28"	1205	402
ROCK ISLAND	1746	2-8-0	SIMPLE	338910	198600	44300	4	63"	16.51'	30"	856	214
	2200	2-8-0	SIMPLE	400870	238850	56150	4	63"	16.51'	32"	964	241
NORFOLK & WESTERN	1059	4-8-0	SIMPLE	316600	200000	42960	4	56"	14.69'	30"	596	149
	1033	4-8-0	SIMPLE	316600	200000	42960	4	56"	14.69'	30"	596	149
	594	4-6-2	SIMPLE	312850	196250	45645	3	68"	17.83'	28"	267	89
	603	4-4-2	SIMPLE	284300	167700	41970	2	79"	20.70'	28"	403	202
	494	4-4-2	SIMPLE	316630	200000	42960	4	56"	14.69'	30"	596	149
PENNA LINES	7204	2-8-0	SIMPLE	336310	193500	46000	4	55"	14.45'	28"	632	158
	7027	4-4-2	SIMPLE	320400	176600	55300	2	77"	20.12'	26"	537	270
	7451	4-4-2	B.C.	351575	207775	61625	2	80"	20.94'	26"		
C.B.&Q.	2703	4-4-2	B.C.	317000	196600	51000	2	78"	20.40'	26"		
	2527	4-4-2	SIMPLE	307400	187000	46500	2	84¼"	22.10'	26"	694	347
N.Y.C.	3235		ELEC.		230000	35250	4					
	18		ELEC.		172500	30000						
	3883	4-4-2	SIMPLE	313000	191000	54400	2	78"	20.40'	26"	650	325
1909 C.B.&Q.	2543	4-4-2	SIMPLE	307400	187000	46500	2	84¼"	22.10'	26"	694	347

TRAIN TABLE 1907.

Rail-Road	Date 1907	Location of Bridge	No. of Bridge tested	Record Number.	Engine Number	Car #1			Car #2			Car #3			Car #4			Car #5		
						Initial & Number	Total Weight	Dist. C.to C.	Initial & Number	Total Weight	Dist C.to C.	Initial & Number	Total Weight	Dist C.to C.	Initial & Number.	Total Weight	Dist C.to C.	Initial & Number	Total Weight	Dist C.to C.
Illinois Central.	8/28	Cedar Falls	1	1-14	1013	I.C. —	29600	38'-8"	I.C —	28500	38'-8"	Caboose	36000	42'-0"						
	8/28	do	1	15-24	904	do			do			do.								
	8/29	Webster Cy. Ia	2-3	25-49	1018	I.C. 19289	92000	38'-8"	C.I.&S. 1038	110000	39'-8"	do								
	8/30	do	2-4	50-74	47	I.C. 21139	108000	39'-8"	I.C. 20681	118000	43'-8"	do.								
	8/31	Wall Lake Ia.	5	75-91	20	I.C. —	112000	39'-8"	Caboose	36000	42'-0"									
	9/2	Grable. Ia	6-7	92-120	34	I.C. —	72000	39'-8"	I.C. —	94000	39'-8"	Caboose	36000	42'-0"						
	9/3	do	7-8	121-145	234	I.C. —	124000	39'-8"	I.C. —	126000	39'-8"	do.								
C.B.&Q.	9/4	Apple River. Ill.	9	146-165	1919	Caboose	35400	36'-8"	Car #98. Three Wheel Truck	102300	69'-11"									
	9/5	do	9	166-207	1921	do			do											
	9/6	do	9	208-234	2527	do			do			After #229 Car #98 Taken off.								
	9/7	do	9	235-264	2523	do														
	9/9	do	9	265-301	1919	C.B.&Q. 39395	87400	37'-8"	Caboose 14098	35400	36'-8"									
	9/10	La Grange Ill	10-11	302-323	2123	Caboose	35400	36'-8"												
	9/11	do	10-11	324-360	2123	do														
C.M.&St.P.	9/2	Byron. Ill.	12	361-392	1703	St.P 76594	120000	43'-6"	St.P. 77888	128000	43'-6"	St.P. 82162	124000	44'-6"	Caboose	36000	50'-6"			
	9/12	Davis Jct. Ill	13	393-404	1703	do			do			do.			do					
	9/13	Byron. Ill	12	405-425	304	St.P. —	70000	36'-0"	St.P. —	128000	43'-6"	St.P. —	95000	36'-0"	do					
	9/13	Davis Jct. Ill	13	426-435	304	do			do			do.			do					
	9/14	Byron. Ill	12	436-462	925	St.P 49247	114000	44'-0"	St.P. 49005	114000	44'-0"	St.P. 275004	148000	44'-0"	do					
Rock Island	9/16	Metz Ia	14-15	463-487	1672	Coach 1048	45300	52'-0"	P.C. #1922	78900	62'-10"									
	9/17	do	14-15	488-525	819	do			do											
Nickel Plate	9/19	Ft. Wayne Ind	16	526-555	147	15124	108600	42'-0"	15450	111,300	42'-0"	14711	105900	42'-0"	14321	105900	42'-0"	Coach —	—	-
	9/20	do	16	556-570	185	do.			do			do.			do.					
	9/20	do	16	571-586	181	do.			do			do.			do.					

TABLE 5—b.

TRAIN TABLE 1908. SHEET 1

Rail-Road.	Date 1908	Location of Bridge.	No of Bridges Tested	Record Number.	Engine Number.	Car #1			Car #2			Car #3			Car #4			Car #5		
						Initial and Number.	Total Weight	Dist C. to C.	Initial and Number	Total Weight	Dist C. to C	Initial and Number	Total Weight	Dist C. to C	Initial and Number	Total Weight	Dist C. to C	Initial and Number	Total Weight	Dist C. to C
C.M.& St.P.	7.14	Byron Ill.	17	600 - 629	263	St. P 32011	145400	45'-3"	St. P 83218	129600	44'-9"	St. P 87308	128800	45'-0"	Caboose 0601	36000	42'-6"			
	7/15	"	"	630 - 649	939	do.			do.			do.			do.					
	7/16	Davis Junc Ill.	19 18	650 - 664	"	do.			do.			do.			do.					
	7/18	Bardwell. Wis	19	665 - 670	263	C&O. 33849	151600	43'-6"	Caboose 0706	36000	42'-6"									
	"	"	"	671 - 676	"	P.R.R 856698	143100	41'-6"	do.											
	7/20	Avalon. Wis.	20	677 - 702	"	Caboose 0706	36000	42'-6"												
Santa Fe.	7/21	Wilbern. Ill	21 22	703 - 723	573	Santa Fe 79407	160000	44'-4"	Santa Fe 82211	150000	44'-4"	Caboose 156	36000	30'-4"						
	7/22	"	21 22	724 - 756	1403	do.			do.			do.								
	7/23	Carrollton Mo	23	757 - 782	1822	Santa Fe 77641	76100	36'-9"	Santa Fe 75923	86100	36'-9"	Santa Fe 86408	80900	36'-9"	Santa Fe 76998	83200	36'-9"	Caboose 568	36000	34'-0"
	7/24	Hardin Mo	24 26	783 - 812	1824	do.			do			do.			do			do.		
	7.25	Carrollton Mo	23	813 - 837	1115	do.			do.			do			do.			do.		
	7/27	Hardin Mo	24 25	838 - 845	542	do			do.			do			do			do.		
	7/27	"	24 25	846 - 860	1115	Santa Fe 77641	76100	36'-9"	Santa Fe. 86408	80900	36'-9"	Santa Fe. 76998	83200	36'-9"	Caboose 568	36000	34'-0"			
	7/29	Purcell Okla	26	861 - 879	1435	Santa Fe 27687	108300	40'-0"	Santa Fe 23122	101500	40'-0"	Santa Fe 33094	114700	40'-0"	Santa Fe 19154	82300	37'-3"	Santa Fe 26674	108000	40'-0"
	7.30	"	26	880 - 910	1066	do.			Santa Fe. 27048	107800	40'-0"	do.			do.			do.		
	7/31	"	27	911 - 940	1434	Santa Fe 32906	113900	40'-0"	Santa Fe 27687	108300	40'-0"	Santa Fe 27048	107800	40'-0"	do.			da		
	8/1	"	27	941 - 959	1066	do.			do			do.			do.			do.		
Rock Island	8.3	Zyba Kas	28 29	960 - 995	1746	Caboose 18319	30000	36'-8"	Coach #608	68800	62'-2"	Private Car 1912	64150	62'-10"						
	8/4	"	28 29	996 - 1026	"	do.			do.			do.								
	8/5	Alma Kas.	30	1027 - 1051	2200	do			do.			do								
	8/6	McFarland Kas	31	1052 - 1079	"	da			do.			do.								
Norfolk & Western.	8/10	Sciotoville O.	32 33	1080 - 1090	1059	N&W 51528	132400	35'-3"	N&W 56077	132400	35'-3"	N&W 58956	128200	35'-3"	N&W 57738	138600	35'-3"	N&W 51149	127200	35'-3"
	8/11	"	32 33	1091 - 1100	594	do.			do			do.			do.			do.		
	-	"	32 33	1101 - 1112	1033	do			do.			do.			do.			do.		
	8/12	Waverly. O.	34 35	1113 - 1153	1059	N&W. 51149	127200	35'-3"	N&W 57738	138600	35'-3"	N&W 58956	128200	35'-3"	N&W 56077	132400	35'-3"	N&W 51528	132400	35'-3"
	8/13	"	34 35	1154 - 1167	603	N&W 57738	138600	35'-3"	N&W 58956	128200	35'-3"	N&W 56077	132400	35'-3"	N&W 51528	132400	35'-3"	Caboose		
	"	"	34 35	1168 - 1183	"	N&W. 58956	128200	35'-3"	N&W. 36077	132400	35'-3"	N&W. 51528	132400	35'-3"	Caboose					
	8/14	Omega Ohio	36	1184 - 1217	"	do.			do.			do.			do.					
	8.15	"	36	1218 - 1241	494	do.			do.			do.			do.					

TABLE 5—b.

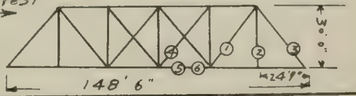
TRAIN TABLE 1908. SHEET 2.

Rail-Road	Date 1908.	Location of Bridge.	No. of Bridges Tested	Record Number.	Engine Number.	Car #1.			Car #2			Car #3			Car #4			Car #5		
						Initial and Number	Total Weight	Dist. C to C	Initial and Number	Total Weight	Dist C to C	Initial and Number	Total Weight	Dist. C to C	Initial and Number	Total Weight	Dist C to C	Initial and Number	Total Weight	Dist. C to C.
Penna. Lines. West.	8/17	Niles Ohio	37	1242-1251	7204	PRR 208251	126700	34'-3"	PRR 150284	131800	35'-0"	P.L. 701503	142900	34'-3"	P.L 706345	137900	34'-3"	PRR 207020	142400	35'-0"
	"	"	37	1252-1268	"	P.L 701503	142900	34'-3"	P.L. 706345	137900	34'-3"	PRR. 207020	142400	35'-0"	Coach 7224			Caboose		
	8/18	"	37	1269-1296	7027	do			do			do			do			do.		
	8/19	Wooster. O.	38 39	1297-1325	7204	PRR 216746	130200	35'-0"	Coach 7224			Caboose								
	"	"	38 39	1326-1336	7027	do			do			do								
	8/20	Winona Lake, Ind.	40	1337-1359	7204	PRR 211319	134800	35'-0"	Coach 7224											
	8/20-8/21	"	40	1360-1390	7027	Coach 7224														
	8/21	Plymouth Ind	41	1391-1410	7204	PRR 211319	134800	35'-0"	Coach 7224											
	8/22	"	41	1411-1423	7451	Coach 7224														
	8/22	"	42	1424-1431	"	PRR 211319	134800	35'-0"	Coach 7224											
	"	"	42	1432 1436	"	Coach 7224														
	8/22-8/24	"	42	1437-1460	7027	do														
	8/24	"	43	1461-1470	"	do														
	"	"	43	1471-1481	7204	do														
	"	"	42	1482-1488	"	do														
	8/25	"	41	1489-1512	7027	do.														
C.B.& Q.	8/26	Apple River, Ill	9	1513-1552	2703	Q 79250	136700	43'-0"	Q 78941	134500	43'-0"	Caboose	36000	35'-6"						
	8/27	"	9	1553-1578	2527	do			do.			do.								
	"	"	9	1579-1601	"	Caboose only														
	8/28	"	9	1602-1613	2703	Q 79250	136700	43'-0"	Q 78941	134500	43'-0"	Caboose	36000	35'-6"						
	"	"	9	1614-1629	"	Caboose only														
N.Y.C.	10/27	Schenectady	44	1700-1709	3235 Electric															
	10/29	"	44	1740-1749	"															
	10/28	"	44	1710-1714	18 Electric															
	10/29	"	44	1715-1739	3883 Electric															
C.B.& Q.	8/16-16 1909.	Belletontaine	45	1801-1835	2543	6 loads @ 144000# each. Coach 100 000#; Private Car 102000*														

TABLE 6—a.

Cedar Falls, Ia. Through, Pin-Connected, Open Floor, Single Track Pratt Truss.
I.C.R.R. Span 148' 6"

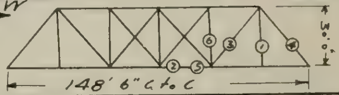
Train Headed West
Bridge #1
Records 1-14
Engine 1013
Date 8-28-07.



Train:-Engine #1013 Class 4-4-2 Pass. Kind:- Simple. Cars:- 2 Empty Box & Caboose.

Instrumnt			Deflection			1				2				3				4						5				6				7	8
Location						Main Diagonal Inside Bar				Hip Vertical Inside Edge				End Post Inside Bottom				2nd Diagonal Inside Bar						Bottom Chord 3rd Panel, Bottom Outside				Bottom Chord 3rd Panel, Top Inside					
																		Tens.			Comp.												
No.	M.P.H.	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R		
1W	21					67	60	12		63	53	19		34	26	31		59	54	9	14			22	16	38		25	19	32			
2E	±15					66		10		60		13		27		4		59		9	15			18		13		22		16			
3W	10					63		5		55		4		27		4		58		7	14			16		0		19		0			
4E	9					58				54		2		24				50			17			14				18					
5W	26					72		20	I	65		23		30		15		59		9				22		38	I	23		21	I		
6E	26					62		3	I	63		19						61		13	16			18		13	I	24		26	I		
7W	30					69		15	I	61		15	I	28		8		62		15	15			18		13	I	24		26	I		
8E	26					67		12	I	63		19	I	29		12		60		11	15			20		25	I	23		21	I		
9W	40					71		18	I	61		15	I	29		12		59		9				23		44	I	24		26	I+		
10E	26					64		7	I	62		17		30		15		60		11	14			16		0	I	24		26	I		
11W	42					64		7	I+	60		13	I	32		23		67		24	14			21		31		24		26	I+		
12E	Very Slow					61		2		54		2		26		0		56		4	14			16		0		19		0			
13W	52									65		23	I	28		8	I	56		4	15			19		19	I	25		32	I+		
14W	50									70		32	I					59		9				19		19	I	25		32	I+		

Train Headed W
Bridge #1
Records 15-24
Engine 904
Date 8-28-07



Train:-Engine #904 Class 2-8-0 Frt. Kind:- Simple. Cars:- 2 Empty Box & Caboose.—

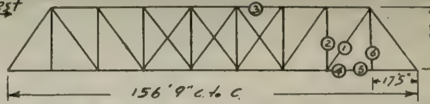
						Hip Vertical Inside East				Bottom Chord 3rd Panel Bottom Outside				Main Diagonal Inside Bar				End Post				Bottom chord 3rd Panel Inside Top				2nd Vertical Inside Edge							
15W	24					76	64	19		22	19	16	I+	62	54	15	M	33	31	6		15	20			18	15	20	18				
16E	24					64		0		24		26	I	59		9	M	33		6		21		5	I	18		20	21				
17W	33					84		31	I+	23		21	I	67		24	I	35		13	I	21		5	I	20		33	31				
18W	33					80		25	I	24		26	I	64		19		37		19	I	24		20		19		27	22				
19W	45					84		31		24		26	I					40		29		21		5		20		33	24				
20W	43					77		20	I	24		26	I+	60		11	I	36		16		20		0	I	19		27	21				
21W	21					66		3		21		10	I	60		11		30				19			I	15		0	20				
22W	14					68		6	I					54		0		32		3		21		5	I	19		27	20				
23W	21					70		9	I	23		21	I+	63		17	I	35		13		20		0	I	22		47	26				
24W	23					76		19	I	23		21	I	59		9		34		10		22		10	I	25		67	25				

TABLE 6—b.

Webster City, Ia Through, Pin-Connected, Open Floor, Single Track
I. C. R.R. Pratt Truss. Span 156'-9"

Train:- Engine #1018 Class 4-4-2 Pass. Kind:- Simple. Cars:- 2 Loaded & Caboose.

Train Headed West
Bridge #2
Records 25-49
Engine 1018
Date 8-29-07

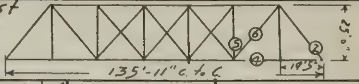


Instrument			Deflection			1				2				3				4				5				6					
Location						Main Diagonal Inside Bar				2nd Pl. Post Inside West				Top Chord 3rd Panel Outside Top				Bottom Chord 2nd Panel Outside Bar				Bottom Chord 2nd Panel Inside Bar				Hip Vertical East Inside					
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		
25W	15					Passenger																									
26E						Freight																									
27W	23					61	60	2	M	65	63	3		34	34	0	I	33	29	14	M	33	30	10	I	38	37	3			
28E	24					62		3	I	69		10		35		3		29		0	I	28			I	38		3			
29W	38					62		3	I	68		8	I	36		6					M I	36		20	I	40		8			
30E	31					66		10	I	70		11		34		0		33		14	M I	29			I	38		3			
31W	36					61	59	3	M	69		10		36		6		31		7	M I	32		7	I	38		3			
32W	38					61		3	M	69		10		36		6	I	30		3	M I	33		10	I	41		11			
33W	21					60		2	M	67		6		39		15		30		3	I	29			I	44		19			
34E						59		0	M	68		8		35		3		30		3	M	27			I	43		16			
35W	27					65	58	12	I	70		11		41		21	I				M I	32		7	I+	50		35			
36W	58					66		14	I	66		5	I								M I	34		13	I+	53		43			
36½	Slow					60		3	I	66		5		38		12															
37	58					66		14	I+	65		3	I	38		12	I				MI	34		13	I+	55		49			
38	64					69	57	21	I+	66		5	I	36		6	I				M I	37		23	I+	52		41			
39	70					75		32		70		11	I								M I	37		23	I						
40	25					60		5	M	65		3		34		0															
41	15					54			M	64		2		34		0															
42	28					61	56	9	M	65		3		34		0															
43	38					69		23	I	65		3		33																	
44	45					62		11		69		10	I	34		0	I														
45	55					62		11	I	74		18	I	36		6	I														
46	60					75	55	36	I+	67		6	I+	36		6	I														
47	66					68		24																							
48	69					68		24	I																						
49	72					68		24	I+																						

Through, Pin-Connected, Open Floor, Single Track Pratt Truss. Span 135'-11"

Train:- Engine #1018 Class 4-4-2 Pass. Kind:- Simple. Cars:- 2 Loaded & Caboose.

Train Headed West
Bridge #3
Records 40-49
Engine 1018.
Date 8-29-07

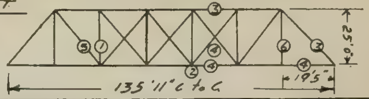


										End Post Bottom Inside								Bottom Chord 2nd Pl Post Outside Bar				2nd Panel Post				Main Diagonal Outside Top					
40	25																	50	48	4	I	55	51	8		47	47	0	M		
41	15																	50		4		52		2		47		0	M		
42	28																	50		4	M	54		6		47		0	M		
43	38																	52		8	I+	54		6		47		0	M		
44	43																	52		8	I	63		24		48		2	M I		
45	55																	49		2	I	58		14		50		6	I		
46	60																	50		4	I+	54		6	I	47		0	I		
47	66									58	50	16	I					50		4	I	56		10		48		2	I+		
48	69									59		18	I					50		4	I+	58		14	I	48		2	I+		
49	72									70		40	I+					50		4	I+	57		31	I	57		21	I		

TABLE 6—c.

Webster City, Ia. Through Pin-Connected, Open Floor, Single Track Pratt Truss.
I.C.R.R.
Span 135'-11"

Train Headed West.
Bridge #4
Records 50-74
Engine 47
Date 8-30-07

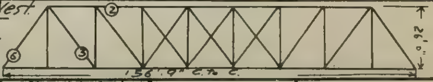


Train:- Engine #47 Class 4-6-0. Pass. Kind:- Simple. Cars:- 2 Loaded & Caboose.

Instrument			Deflection			1				2				3				4				5				6			
Location						2nd Pl. Post Inside East				Floor Beam, 3rd Pl. Point West Flange				End Post Inside Top				Bottom Chord 1st Panel Inside Bar.				Main Diagonal Inside Bar				Hip Vertical West Inside			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
50	18					51	44	16		46	35	31		16	16	0						45	45	0		46	42	10	
1	24					49		11		46		31		19		19						51		13		46		10	I
2	30					54		23		40		14		19		19						48		7	I	49		17	
3	34					54		23		53		52		18		13						50		11					
4	49					49		11		47		35	I	19		19						48		7	I	48		14	I
55	59					52		18		47		35		19		19	I					48		7	I	45		8	I
6	48					47		7	I	45		28	I	19		19	I					51		13	I	47		12	I
7	58					53		20		50		43	I	19		19	I					50		11	I	48		14	I
8	24					52		18		44		25		18		13						47		4		43		2	
9	23					51		16		45		28		18		13						46		2		43		2	
														Top Chord, 3rd Panel Inside Top				North Stringer 3rd Panel Inside Edge											
60	57					54	44	23		45		29		47	35	34						49		9	I+	46		10	I+
1	±45		Local Passenger																										
2	15					43				45		29		37		6		27	27	0		46		2		43		2	
3	30					52		18		42		20		42		20	I	37		37	I	46		2		49		17	
4	34					53		20		43		23		41		17	I+	37		37	I	49		9	I	46		10	I
65	43					49		11		47		35	I	43		28	I+	38		41	I	52		16	I	48		14	I
6	55					49		11	I	47		35	I	39		11	I+	34		26	I+	54		20	I	41			I+
7	59					49		11	I	44		20	I					27		0	I+	52		16	M+	42		0	I+
8	60																	40		48	I+	52		16	M+				
9	61					52		18	I									32		19	I+	54		20	M+				
70	56					45		2										31		15	I	49		9	M				
																		Bottom Chord 3rd Panel Inside Bar											
71	61					51		16										32	25	28	I	57		27	I				
2	61					46		5	I									30		20	I	50		11	I+				
3	32					44		0										29		16	I	50		11	I				
4	29					44		0		Top Chord, 3rd Panel				Main Diagonal				26		4	I	48		7		End. Post Inside Top			

Through Pin-Connected, Open Floor, Single Track Pratt Truss. Span 156'-9"

Train Headed West.
Bridge #2
Records 68-74
Engine 47
Date 8-30-07

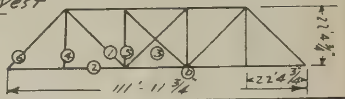


No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
68														50	36	38										26	14	86	I
9										44	34	29	I+	49		36										20		43	
70										36		6		40		11										17		21	
1										37		9	I																
2										36		6	I	42		17	I									18		29	I
3										34		0		39		8										16		14	I
4										34		0		38		6										13			I

TABLE 6—d.

Wall Lake, Ia. Through, Skew, Pin-Connected, Shallow Suspended
I.C.R.R. I Beam Open Floor, Single Track, 1 Heavy & 1 Light Truss. Span 111'-11¾"
Train:- Engine #20 Class 4-6-0. Kind:- Simple. Cars:- 1 Loaded & Caboose.

Train Headed West
Bridge #5
Records 75-91
Engine #20
Date 8-31-07

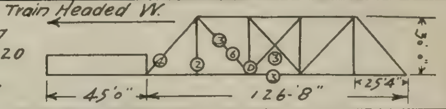


Instrument			Deflection			1				2				3				4				5				6			
Location			2nd Pl. Point from West			Main Diagonal Inside Bar				Bottom Chord 2nd Panel Inside Bottom				Stringer 2nd Panel				Hip Vertical Inside Bar				2nd Pl. Post East Inside				End Post Inside Bottom			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
75	48		80	61	31													Large Instrumental Vibration				Curves not satisfactory				29	26	12	I
6	20		66		8	44	40	10	I	21	17	24	I													26		0	I
7	26		73		20	46		15	M+	19		12	I													29		12	
8	33		65		7	43		8	M	20		18														28		8	I
9	55		77		26	48		20	I+					49	30	63													
80	13		65		7	41	39	5		18		6		30		0										30		17	
1	23		64	60	7	37			M+	18		6	I	30		0										25	25	0	I
2	29		65		8	37			M	18		6	I	33		10										28		12	I
3	51		84		42				M					42		40										34		36	I
4	57		77		28	47	38	24	I					43		43										36		44	I
85	39		68		13	44		16	I					40		33										29		16	I
6	38		69		15	43		13	I	21		24	M	41		37										29		6	I
7	31		66	59	12	43		13	I	19		12	M	33		10										31	24	24	I
8	27		65	58	12	38	37	3	M+	18		6	M	30		0	I									28		17	I
9	39		71		22	41		11	M+	25		47	M	35		17	I									27		13	I
90	15		58	57	2	36			I	17		0	M	27												25		4	I
1	22		61		7	38		3	M	15			M	32		7	I									24		0	I

TABLE 6—e.

Grable, Ia. Through, Pin-Connected, Single Track, Open Floor.
(1 Heavy & 1 Light Truss) Span 126'8"
I.C.R.R. Through, Open Floor, Plate Girder. Span 45' 0."
Train:- Engine #34. Class 4-6-0. Kind:- Simple. Cars:- 2 Loaded & Caboose.

Bridges #6-7
Records 92-120
Engine 34
Date 9-2-07.



Instrument			Deflection			1				2				3				4				5				6					
Location			2nd Pl. Point from West End			Plate Girder Outside Bottom Center				Hip Vertical Inside South				Bottom Chord Center Panel Inside Top				End Post Inside Bottom				Plate Girder Outside Top Center				Main Diagonal Inside Bar					
No.	MPH	L.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		
92	3		56	56	0	36	42			36	33	9		8	9											37	35	6			
93	6					44		5		34		3		9		0						34	36								
4	10		58	55	5	42		0		38		15		7				4				32				37		6			
95	15		55	54	2	44		5		37		12		7								39		8		39		11			
6	18					48		14		38		15		9		0		6				39		8		37		6			
7	23		55	53	4	46		10		37		12		10		11		5				39		8		40		14			
8	25					52		24		39		18		13		44		6				40		11		39		11			
9	30		55	52	6	44		5		39		18		10		11		7				41		14	I	39		11			
100	37		67	61	10	47		12		42		27	I	14		56		8				40		11	I	40		14			
1	40		71	61	16	49		17		40		21	I	13		44		12				38		6		41		17			
2	45		71	60	18	54		29		47		42	I	13		44		13				47		31	I	40		14			
3	46		68	59	15	60		43	I	49		48		13		44		13				48		33	I	41		17			
4	52		82	56	41	60		43		51		54		14		56		13				48		33	I	41		17			
105	59					60		43		43		30	I	13		44						53		47	I	41		17			
			3' West of Center of Girder											Stringer Center Panel																	
106	50		Passenger Train West																												
7	55		52	36	45	63		50		45		36	I	26	21	24						50		39	I	45		28			
																		Plate Girder Center Outside Top													
108	51		50		39	58		38		45		36		26		24		54	35	54	I	54		50		41		17			
9	46		45		25	56		33		48		45		36		71	I	42		20	I	50		39		42		20			
110	41		42		17	51		21		42		27	I	27		29		40		14	I	42		17	I	42		20			
1	36		41		14	45		7		35		6	I	35		67		41		17	I	41		14	I	39		11			
2	33		42		17	50		19		37		12	I					41		17	I	45		25	I	38		9			
3	23		42		17	44		5		35		6						37		6		39		8	I	38		9			
														Main Diagonal																	
114	40		40		11	49		17		37		12	I					44		26	I	42		17	I	42		20			
115	45		43		19	49		17		48		45		53	40	33		44		26		42		17	I	46		31			
6	41		46		28	55		31		41		24		42		5	I	49		40	I	44		22	I	43		23			
7	39		42		17	52		24		43		30	I	45		13		40		14	I+	44		22	I	47		34			
8	28		40		11	43		2		35		6	I	43		8	I	38		9	I	39		8		41		17			
9	20		36		0	43		2		35		6		43		8		34			I	37		3		39		11			
120	13					42		0		34		3		40		0		33				37		3		35		0			

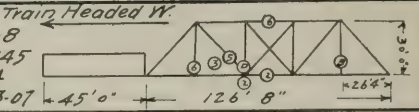
TABLE 6—f.

Grable, Ia. Through, Pin-Connected Single Track, Open Floor, (1 Heavy - 1 Light Truss) Span 126'-8"

I.C.R.R. Through Plate Girder, Open Floor. Span 45'0"

Bridges #7-8
Records 121-145
Engine 234

Train:- Engine #234. Class 4-6-0. Kind:- Simple. Cars:- 2 Loaded & Caboose. Date 9-3-07

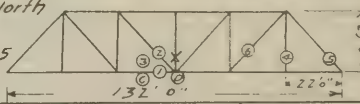


Instrument			Deflection			1				2				3				4				5				6			
Location			2' North of Center of Girder			Plate Girder Center Outside Bottom				Bottom Chord Center Panel Outside Top				Stringer 2nd Panel Outside Bottom				Plate Girder Center Outside Top				Main Diagonal Inside Bar				So. Hip Vertical So. Ins. Edge			
No	MRH.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
121	50			Passenger East																									
2	45			Passenger West																									
3	50		50	36	39	53	41	29		37	25	48	I	42	20	110		45	33	36		63	48	31	I	50	40	25	I
4	8		33			41		0		26		4		20		0		27				48		0		42		5	
125	14		37		3	46		12		25		0		20		0		33		0		45.				42		5	
6	18		38		6	44		7		26		4	I	21		5		32				48		0		44		10	
7	22		39		8	49		20		24			I	23		15		34		3		48		0		40		0	I
8	27		43		19	49		20		28		12	I	27		35		38		15		48		0		42		5	I
9	30		47		31. Girder	55		34		28		12	I	26		30		43		30		48		0	M	43		8	
130	38		41		14	52		27		28		12	I	25		25	I	44		33	I	49		2	M	42		5	I
1	41		46		28	54		34		28		12	I	25		25	I	46		39	I	53		10	I	37			I
2	51		57		58	58		41		28		12	I	37		85		42		27	I	58		21	I	43		8	I+
3	55		52		44	60		46						31		55	I	51		54		56		17	I	42		5	I
										Floor Beam 2nd Pl Point																			
134	55		45		25	61		49		38	31	23		32		60	I	50		51	I	59		23		47		18	I+
5	53		59		61	62		51		40		29	I	38		90	I	43		30		56		17	I	45		12	I
			2nd Pl. Point from West End																							Top Chord Center Panel Outside Top			
136	53		89	76	17	65		58		39		26	I	42		110	I	45		36		55		15	I	42	32	31	
																						Hip Vertical North Inside							
137	53					63		54		35		13	I	36		80	I	48			I	49	29	69	I	42		31	I
8	50				Truss	61		49		41		32		38		90		49			I	42		45	I+	42		31	
9	47					57		39		39		26	I	28		40	I	53				42		45	I+				
140	45									40		29	I	40		100		42				40		38	I	42		31	I
1	42^5					60		46		38		23	I	32		60	I	45				42		45	I	38		19	
2	31					48		17		34		10		25		25	I					40		38		38		6	
3	25					48		17		35		13		28		40	I	42				37		28		34		6	I
4	22									33		6	I	24		20	I	37				32		10		35		9	
145	12					42		2		31		0		24		20		37				29		0		32		0	

Table 6—g.

Apple River, Ill Through, Pin-Connected, Open Floor, Single Track.
C. B. & Q Span 132'-0"

Train Headed North
Bridge #9
Records 146-165
Engine 1919



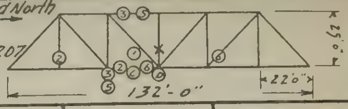
Train:- Engine # 1919 Class 2-6-2. Kind:- Simple Cars:- Caboose & Private Car. Date 9-4-08

Instrument			Deflection			1				2						3				4				5				6					
Location			Center Panel Point			Bottom Chord 3rd Panel				Diagonal 3rd Pl. Outside Top						Stringer 3rd Panel				Hip Vertical North Inside				End Post Inside Bottom				Main Diagonal Inside Top					
										Comp			Tens-																				
No.	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		
146	Slow		140	140	0	35	33	6		31	30	3	22			42	48			43	48			30	32			75	74	1			
7	8		143	140	2	34		3		32		7	27			48		0		51		6		31				74		0			
8	12		141	139	1	34		3		32		7	28			57		6		54		13		32		0		80		8			
9	17		145	138	5	38		15		31		3	30			55		15		53		10		34		6		78		5			
150	22		142	138	3	37		12		32		7	32			62		29		61		27		36	31	16		77		4			
1	24		144	137	5	36		9		33		10	29			53		10		61		27		36		16		80	73	10			
2	30		150	136	10	38		15		35		17	29			52		8		63		31		38		23		80		10			
3	36		169	136	24	40		21		39		30	39			58		21		66		37		44		42		83		14			
4.	42.5		171	135	29	44		33		39		30	32			55		15		73		51		39		26		86		18			
155	49	6.5S	151	135	12	41		24		36		20	32			54		13	I	75		56		39	30	30		83	72	15			
6	42.5	7.6S	168	134	25	45	32	41		34		13	35			48		0		83		73		37		23		89		24			
7	41.5	0.1S	168	131	28	44		37		45		50	31			70		46		81		69		38		27		86		20			
8	46	1.7S	150	130	15	39		19	I	45		50	35			65		35		79		64		34		13		82		14	I		
9	49	1.8S.	149	128	16	37		16		37		23	36			70		46		72		50		37		23		83	71	17			
										Floor Beam 1st Pl Point East Flange																							
160	50	3.4S	148		16	40	30	33								70		46		67		40		36	29	24		79		11	I		
1	50	5.1S	150		17	40		33		48	42	14				69		44		66		37		36		24		80		13	I		
2	50	6.2S	152		19	43		43	I	51		21				68		42		78		62		36		24		81	70	13	I		
3	51.5	6.6S	153		20	43		43		51		21				60		25		72		50		37		27		82		17			
4	17	4.8S	135	125	8	32	28	14		44		5				50		4		55		15		28	28	0		73		4	I		
165	24	1.8N.	130	125	4	33		18		48		14				59		23		55		15		29		3		75		7	I		

TABLE 6—h.

Apple River, Ill. Through, Pin-Connected, Open Floor, Single Track. Span 132'-0"
C. B. & Q.
Train:- Engine #1921 Class 2-6-2. Kind:- Simple. Cars:- Caboose & Private Car.

Train Headed North
Bridge #9
Records 166-207
Engine 1921
Date 9-5-07.



Instrument			Deflection			1				2				3				4				5				6			
Location			Center Panel Point			Stringer 3rd Panel				Hip Vertical West Inside				Floor Beam 2nd Pl Point So. Flange				Lower Chord 3rd Pl. Top Flange				Floor Beam 2nd Pl. Point North Flange				Main Diagonal Inside Top			
No	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
166	13	0.5S	144	138	4	58	58	0		63	65			45	42	7		22	22	0		52	50	4		80	75	7	I
7	18	1.0S	145		5	69		19		69		6		41				23		5		50		0		77		3	I
8	24	1.8S	140	137	2	66		14		71		9		43		2		21				53		6		79		5	I
9	27	2.5S	140		9	65		12		73		12		45		7		25		14		55		10		80		7	I
170	29	3.4S	143		4	64		10		78		20	I	46		10		25		14		56		12		79		5	I
1	34	4.5S	152	136	12	62		7		76		17	I	46		10		25		14		55		10		79		5	Nt
2	36	5.8S	165		21	66		14		77		18		45		7		28		27		52		4		93		24	
3	35	7.3S	165		21	72		24		76		17	I	45		7		29		32		52		4		93		24	I
4	44	9.1S	167	135	24	75		29		83		28		48		14	I	32		45		58		16		93		24	I
175	45	7.3N	167		24					90		38		47		12	I	35		59		63		26		93		24	I
6	53	5.3N	153		21	89		53		91		40		52		24						63		26		71			I
7	53	3.6N	147	134	10	80		38		83		28		47		12	I					63		26					
8	55	1.9N	146		9	85		46		80		23		55		31						60		20					
9	47	0.1S	150		12	90		55		75		15		48		14	I					57		14		80		7	I
180	50	2.6S	152		13	90		55		77		18		48		14	I					53		6		80		7	
1	46	4.9S	160		19	70		21		75		15	I	49		17						52		4		85		13	I
2	46	5.4S	158		19	73		26		82		26		52		24						61		22		83		11	It
3	30	8.2S	145	133	9	66		14		79		22	I	43		2						56		12		80		7	I
4	22	8.7S	137		3	65		12	I	74		14		46		10						55		10		75		0	I
185	16	8.9S	142		7	58		0		69		6		42		0						51		2		74			I
6	14	9.1S	141		6	61		5		70		8		42		0						50		0		80		7	
										Bottom Chord 3rd Pl. Inside Bottom																Bottom Chord 3rd Pl. Inside Top			
187	173	8.4N	134		1	62		7		46	45	2		42		0						52		4		28	30		
8	32	6.5N	144		8	70		21		49		9		42		0						53		6		33		10	I
9	43	3.8N	165		22	69		19		56		24		47		12	I					60		20		40		33	I
190	44	1.2N	158		19	71		22		56		24		46		10	I					59		18		37		23	I
1	50	1.7S	155		17	90		55		58		29		48		14	I					53		6		37		23	
														Top Chord 3rd Pl Inside Bottom								Top Chord 3rd Panel Inside Top							
192	15	1.2S	142	132	8	61		5	I	45		0		51	46	11										33		10	
3	27	2.4S	147		11	61		5	I	46		2		51		11										33		10	
4	33	0.1S	147		11	62		7		47		4		51		11										37		23	I
195	43	3.4S	170		29	73		26		54		20	I	60		30										41		37	I
6	49	7.0S	158		20	63		9		53		18		59		28										40		33	
7	50	7.9N	142		8	52			I	51		13		56		22	I									41		37	I
8	49	5.7N	151	131	15	61		5	I	56		24		56		22	I									39		30	I
9	50	3.4N	149		14	73		26		55		22		55		20	I									41		37	I
200	52	1.1N	146		11	78		34		56		24		51		11	I									38		27	I
1	50	0.5S	165		26	76		31		54		20														41		39	I
2	50	0.8S	150		24	79		36		52		16		52		13	I					82	70	17	I	36		20	I
3	50	3.7S	155		18	84		45		55		22		54		17						87		24		38		27	I
4	44	5.3S	160	130	23	66		14		52		16		59		28						90		29		39		30	I
205	43	4.7S	160		23	68		17		53		18		57		24						91		30		38		27	
6	23	4.5S	133		2	62		7	I	44				46		0						71		1		32		7	
7	15	4.4S	134		3	57				44				46		0						70		0		30		0	

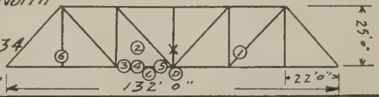
TABLE 6—i.

Apple River, Ill. Through, Single Track, Pin-Connected, Open Floor Truss
C. B. & Q.

Span 132'-0"

Train Headed North
Bridge # 9
Records 208-234
Engine 2527

Train:- Engine # 2527 Class 4-4-2. Kind:- Simple. Cars:- Caboose & Private Car. Date 9-6-07

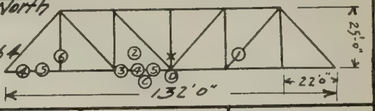


Instrument			Deflection			1				2				3				4				5				6					
Location			Center Panel Point			Main Diagonal Inside Bottom				Stringer 3rd Panel				Bottom Chord 3rd Panel Inside Bottom				Bottom Chord 3rd Panel Outside Top				Bottom Chord 3rd Panel Inside Top				Hip Vertical Inside Bar					
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		
208	9	3.7N	127	127	0					43	44			39	36	8						17	17	0		62	60	3			
9	12	7.3N	126	126	0	62	62	0		45		2		35								17		0		60		0			
210	16	5.4N	130		3	64		3		47		7		37		3						17		0		60		0			
1	20	3.8N	129		2	65		5		50		14		39		8						19		12		60		0			
2	25	0.6N	128		2	63		2		50		14		39		8						21		24		64		7			
3	31	7.8N	129		2	67		8	M	47		7	I	39		8						19		12		66		10			
4	34	6.0N	140	125	12	70		13	M	53		20	I	43		19						24		41		65		8			
215	44	0.9N	147		18	73		18		45		2	I	45		25						28		65		70		17	I		
6	45	2.1S	155		24	74		19		55		25	I	46		28						26		53		79		32			
7	52	5.4N	144		15	73		18		75		70		45		25						25		47		80		33			
8	52	3.7S	142	124	15	70		13		70		59		46		28										79		32			
9	59	2.2N	130	123	6					50		14	I	43		19						26		53							
220	36	6.9N	144	127	13					52		18		42		17		40	30	33		26		53		79		32	I		
1	44	2.9N	155		22					48		9	I	48		33		36		20	I	32		88		75		25	I		
2	43	1.9N	149	126	18					46		5	I	49		36		39		30		29		70		77		28			
3	47	5.6S	154		22					65		48		48		33		39		30	I	29		70		79		32	I		
4	49	9.6N	145	125	16					50		14	I	45		25		39		30		29		70		78		30			
225	53	4.9N	147		18					68		55		45		25		42		40	I	28		65		82		37			
6	57	0.5N	145	124	17					72		64		45		25		49		33		28		65		72		20			
7	65	10.0S	130		5					57		30						36		20	I	26		53	I	83		38	I		
8	57	6.1N	128	123	4					40				45		25		36		20	I	24		41	I	108		80			
9	53	9.2N	140	115	22					54		23		48		33		40		33	I	28		65		74		23	I		
						Private Car taken off																									
230	25	3.2N	118	114	4					46		5	I	35	32	9		33	27	10		20	16	25		67		12			
1	27	1.9N	115		1					48		9		36		12		30		0		21		31		67		12			
2	47	2.7S	139	113	23					56		27		39		22		35		17		27		69		85		42	I		
3	47	6.4S	150	112	34					64		45		45		41		38		27	I	29		81		85		42	I		
4	44	7.4S	139		24					50		24		43		34		38		27	I	27		69		77		28	I		

TABLE 6—j.

Apple River, Ill. Through, Pin-Connected, Single Track, Open Floor.
C. B. & Q. Pratt Truss. Span 132'0"
Train:- Engine #2523 Class 4-4-2. Kind:- Simple. Cars:- Caboose.

Train Headed North
Bridge #9
Records 235-264
Engine 2523
Date 9-7-07.

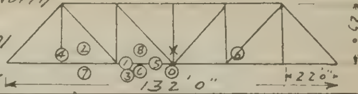


Instrument			Deflection			1				2				3				4				5				6					
Location			Center Panel Point			Main Diagonal Inside Bar				Stringer 3rd Panel				Bottom Chord 3rd Panel Inside Bottom				Bottom Chord 3rd Panel Inside Top				Bottom Chord 3rd Panel Outside Top				Hip Vertical Inside Bar					
No	M.P.H.	C.B.	M.	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		
235	38	3.5S	135	125	8	71	60	18		48	44	9	I	39	39	0	I	34	30	13		30	27	11							
6	48	8.5S	146		17	72		20		50		14	I	46		18	I	38		27		35		30		70	58	21			
7	48	7.3N	135		8	69		15		58		32	I	46		18	I	34		13	I	32		18		73		26	I		
8	13	5.6N	130		3	63		5		45		2		35				29				25				55					
9	31	0.1S	137		10	63		5	M	55		25			38			31		3		27		0		63		9	I		
240	44	8.7S	147		18	70		17		49		11	I	48		26		37		23		34		26		65		12	I		
1	29	7.9S	130		4	62		3	I	49		11	I	40		5		31		3		28		4		61		5	I		
242	13	4.4S	126		1	61		2		44		0		38	37	3		33	30	10		9	9	0		58		0	I		
3	10		126		1	60		0		44		0		37		0		31		3		9		0		57					
4	10	8.6S	127		2	63		5		45		2	I	36				30		0		9		0		57					
245	24	1.6S	132		6	63		5		48		9	I	39		5		32		7		10		11		58		0	I		
6	20	8.4S	128	124	3	62		3		45		2	I	37		0		31	29	7		10		11		58		0			
7	28	10.0S	130		5	64		7	I	50		14	I	40	36	11		32		10		11		22		60		3	I		
8	28	1.5S	130		5	64		7		48		9	I	38		6		32		10		13		44		60		3	I		
9	33	0.0	138		11	62		3	M	48		9	I	40		11	I	32		10		11		22		61		5	I		
250	33	2.7N	139		12	63		5	M	48		9	I	41		14	I	34		17		10		11		62		7	I		
1	36	1.9N	140		15	69		15	I	48		9	I	42		17		34	28	21	I	13		44		63		9	I		
2	34	8.5S	130		5	65		8		48		9	I	40		11		33		18		11		22		63		9	I		
3	37	1.9N	143		15	75		25		55		25	I	43	35	23	I	33		18		11		22		66		14	I		
4	39	1.9S	140	123	14	68		13		46		5	I	43		23		34		21	I	11		22		70		21			
255	57	6.9S	138		12	69		15		51		16		42		20	I	38	27	41		10		11		80		38			
6	55	4.9S	142		15	69		15		53		20	I	42		20	I	40		48	I	12		33		72		23			
7	30	2.4N	130		6	61		2		48		9	I	36		3	I	29		7		10		11		60		3	I		
8	30	5.4N	130	122	7	63		5		46		5	I	38		9	I	30		11		10		11		58		0	I		
9	40	6.2N	143		17	73		22		52		18	I	41	34	21	I	34		26		11		22		63		9			
260	42	2.7N	141		16	69		15		50		14	I	42		24		32	26	23		10		11		65		12			
1	42	7.7S	140	121	16	71		18		49		11	I	45		32	I	33		27		12		33		66		14			
2	42	5.4S	139	120	16	70		17		60		36	I	42		24	I	34		31		13		44		80		38			
3	10	5.3S	119	119	0	58				43				34		0		25				9		0		55					
4	16	3.6N	120	118	2	58				44		0	I	35		3						9		0		58		0			

TABLE 6—k.

Apple River, Ill. Through, Pin-Connected, Single Track, Open Floor,
C.B. & Q. Pratt Truss. Span 132'0"
Train:- Engine # 1919 Class 2-6-2. Kind:- Simple. Cars - 1 Loaded & Caboose. Date 9-9-07

Train Headed North
Bridge # 9
Records 265-301
Engine 1919

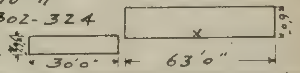


Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			Bottom Chord near Center Pl Point			Bottom Chord 3rd Panel Inside Top				East Stringer 2nd Panel East Flange				East Stringer 3rd Panel East Flange				Hip Vertical Inside Bar				Bottom Chord 3rd Panel Outside Bottom				Main Diagonal Inside Bar				East Stringer 2nd Pl. West Flange				East Stringer 3rd Pl West Flange			
NO	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
265	7	3.4S	150	147	2					60	57	5		49	51			66	67			43	41	5		81	78	4		56	50	12		50	50	0	
6	9	3.4S	153		4	22								50				67		0		43		5						54		8		52		4	
7	20	3.9S	150		2	24				65		14		52		2		71		6		47		15		78		0		59		18	I	51		2	
8	20	4.2S	148	146	1	22				57		18	I	54		6		75		12		48		17		79		1		62		24	I	49			I
9	26	4.8S	150		3	23				63		11	I	57		12		79		18		44		7		78		0		56		12	I	51		2	
270	26	5.1S	150	145	3	23				62		9	I	60		18		81		21		45		10		81		4		54		8	I	52		4	
1	30	5.8S	157		8	26				69		21	I	60		18		80		19		46		12	I	85		9		57		14	I	52		4	
2	31	6.3S	158		9	25				65		14	I	67		22		77		15		53		29		90		15		54		8	I	53		6	I
3	36	7.4S	180	144	25	31	30	3		63		11	I	66		29		81		21	I	62		51		106		36		61		22	I	50		0	I
4	33	7.8S	166		15	35		17		64		12	I	67		31		81		21	I	58		41						59		18	I	55		10	
275	39	9.0N	183		27	31		3		60		5	I	63		24		85		27	I	59		44		100	77	30		65		30	I	65		30	
6	37	8.2N	181	143	27	29	29	0		55			I	72		41		76		13	I	63		54		102		32		63		26		52		4	I
7	39	7.0N	188		31	34		17		58		2	I	63		24		86		28	I	65		58		101		31	I	70		40		59		18	I
8	39	6.2N	183		28	35		21		58		2	I	67		31		87		30	I	62		51		104		35		70		40	I+	62		24	I
9	45	5.8N	162	142	14	28				100		75	I	71		39		86		28	I	50		22	I	88		14	I	36			I+	80		60	
280	47	3.6N	158		11	28				109		91		73		43		88		32	I	55		34		86		12		50		0	I	62		24	I
1	33	4.4N	159		12	25				60		5	I	70		37		74		10	I	48		17		95		23		61		22		53		6	I
2	35	3.6N	163	141	16	28	28	0		73		28	I	78		53		76		13	I	50		22		92		20		65		30	I	53		6	
3	35	2.8N	170		21	28		0		75		32	I	67		31		82		22		52		27		96		25		65		30	I	60		20	I
4	35	2.2N	165		17	28		0		75		32	I	70		37		80		19	I	52		27		94	76	25		32				59		18	I
285	34	2.1N	174	140	24	30		7		85		49		78		53		88		32		59		44		102		34		78		56	I+	70		40	I
6	40	1.0N	170		21	35		25		88		54		73		43		84		25	I	59		44						66		32	I+	77		54	
7	40		173	139	24	39		39		87		53		69		35		90		34		61		49		97		28	I	73		46	I+	71		42	
8	40	1.8S	170		22	46		64		81		42		68		33		81		21	I	60		46		95		23		67		34	I	66		32	
9	46	3.1S	150	138	9	42		50	I					63		24		91		36	I	54		32		85		12		45			I+	69		38	
290	43	3.6S	152		10	39		39						65		27		91		36		48		17	I	84		10		51		2	I	71		42	
1	10	2.3S	138	137		30	30	0		55				52		2		68		2		41		0		75	75	0		53		6	I	49			
2	11	2.3S	139			31		3		56				50				69		3		40								54		8		50		0	
3	16	2.5S	140	136	3	37		23		60		5	I	53		4						44		7		76		1		51		2	I	51		2	
4	15	1.0S	140			32		7		59		4	I	52		2		69		3						76		1		56		12	I	54		8	
295	25	1.7S	143	135	6	31		3		62		9	I	53		4		71		6						79		5		51		2		51		2	
6	20	1.5S	138		2	34		13		63		11	I	57		12		73		9		42		2		77		3		56		12		51		2	
7	25	2.0S	146	134	9	35		17		63		11	I	55		8		74		10		46		12		83		11		56		12	I	51		2	I
8	27	2.6S	143		7	34		13		73		28	I	50			I	81		21	I	45		10		85		13		53		6	I	51		2	
9	46	3.5S	152	133	14	35		17	I	96		68	1	60		18		92		37		45		10		86		9	I	49			I	70		40	I
300	40	4.8S	165		22	41		37	I	76		33		57		12		88		31		56		37	1	95		27	I	63		26	I	60		20	I
1	48	5.4S	146	132	11	41		37		93		63		61		20		89		33		51		24		76		1		49			I	46			I

TABLE 6—1.

La Grange, Ill. Deck Plate Girder, Open Floor, Single Track. Span 30' 0"
C. B. & Q Through Plate Girder, Open Floor, Double Track. Span 63' 0"
Train:- Engine 2123 Class 2-6-2. Kind:- Simple. Cars:- Caboose.

Train Headed E.
Bridges 10-11
Records 302-324
Engine 2123
Date 9-10-07



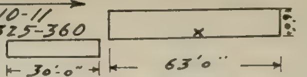
Instrument			Deflection			1				2				3				4				5				6				7				8			
Location —			Center of North Girder East Span			North Girder East Span Inside Top				South Girder West Span, Outside Bottom				South Girder East Span Inside Top				North Girder West Span, Outside Bottom				North Girder East Span Inside Bottom				North Girder West Span, Inside Bottom				South Girder West Span, Inside Bottom				South Girder East Span, Inside Bottom			
NO.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
302	13	8.8E	32	31	3	28	24	17						20	16	25																		25	24	4.	
3	11	3 0W	30			25		4						19		19																		24		0	
4	8	0.6E	31		0	23								17		6																		26		8	
305	8	2.8E	31		0	23								16		0																		24		0	
6	10	5.4W	32		3	24		0						18		13																		24		0	
7	12	6.0E	33		6									17		6																		26		8	
8	14	7.2W	33		6									17		6																		24		0	
9	15	7.3W	33		6	27		13	I					21		31																		24		0	
310	18	6.2W	34		10	27		13						22		38																		25		4	
1	16	7.3E	31		0	25		4	I					17		6						20	20	0										25		4	
2	21	3.4W	35		13	28		17						19		19						20		0										25		4	
3	18	33E	31		0	26		8						17		6						20		0										25		4	
4	20	4.9E	34		10	27		13	I					18		13						21		5										25		4	
315	21	2.1E	36		16	28		17						19		19						21		5										25		4	
6	22	10E	34		10	27		13						18		13						22		10										25		4	
7	26	7.6E	34		10	28		17	I					20		25						22		10										28		17	
8	23	7.6E	30			28		17						18		13						22		10										26		8	
9	22	1.6E	34		10	27		13	I					22		38						23		15										26		8	
320	25	1.2W	34.		10	28		17						21		31						23		15	I									28		17	
1	38	9.0W	33		6	25		4	I					21		31	I					23		15	I									25		4	
2	38	1.4E	31		0	28		17	I					22		38	I					24		20	I									28		17	
3	50	8.7E	32		3	27		13	I					23		43						22		10										29		21	
4	50	4.7E																																			

Deflections on E. Girder

Records of instruments 2, 4, 6 and 7 of little value-
Instrumental vibration too large.

La Grange, Ill. Deck Plate Girder, Open Floor, Single Track. Span 30'0"
C B & Q. Through, Double Track, Open Floor, Plate Girder. Span 63'0"
Train:- Engine # 2123. Class 2-6-2. Kind:- Simple. Cars:- Caboose

Train Headed E →
Bridges 10-11
Records 325-360
Engine 2123
Date 9-11-07



Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			Center of North Girder East Span			North Girder East Span Inside Top				South Girder West Span Outside Bottom				South Girder East Span Inside Top				North Girder West Span Outside Bottom				North Girder East Span Inside Bottom				North Girder West Span Inside Bottom				South Girder West Span Inside Bottom				South Girder East Span Inside Bottom			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
325	11	4.6E	30	31		25	24	4	I						21								18											23	24		
6	15	5.0E	32		3	27		12	I					21		0						18	18	0										25		4	
7	23	3.4E	34		10	29		21	I					24		14						19		6										24		0	
8	19	1.4W	34		10	23			I+					25		19	I					19		6										25		4	
9	22	5.0W	34		10	27		12	I+					23		10						21		17										26		8	
330	27	3.0W	38		23	32		33	I					24		14	I					22		22										27		12	
1	27	8.6W	36		16	29		21	I					24		14	I					20		11										29		21	
2	30	6.4W	35		13	28		17	I					28		33						22		22										27		12	
3	26	5.6W	36		16	30		25	I					26		24						20		11										27		12	
4	31	6.8W	35		13	30		25	I					25		19						22		22										30		25	
335	33	7.9E	35		13																																
6	36	2.4E	33		6	32		33	I+				Instrument too vibratory	22		5	I				Instrument too vibratory	22		22					Instrument too vibratory				Instrument too vibratory	25		4	
7	40	5.4W	35		13	30		25	I					22		5						21		17										24		0	
8	48	6.4E	40		29	28		17	I					27		29	I					22		22										28		17	
9	45	3.2E	35		13	30		25	I					24		14	I					22		22										28		17	
340	49	1.4E	34		10	30		25	I					23		10	I					20		11										27		12	
1	55	2.4W	36		16				I					22		5	I+					22		22	I									27		12	
2	59	1.6W	37		19	30		25	I					30		43	I					23		28										29		21	
3	12	0.1W	30			25		4	I					21		0						18		0										24		0	
4	20	0.4W	37		3	29		21	I					26		24	I					20		11										25	23	9	
345	25	5.8E	36		16	26		8	I					22		5						20		11										25		9	I
6	22	5.0E	32		3	27		12	I					20								20		11										25		9	
7	27	7.0E	38		23									23		10	I					25		39										28		22	
8	28	3.8E	35		13	28		17	I					24		14	I					19		6										24		4	
9	28	1.2E	34		10	30		25	I					25		19	I					19		6										25		9	
350	31	0.4W	36		16	30		25	I					22		5	I					21		17										24		4	
1	31	5.8W	34		10	31		29	I					23		10	I					21		17										25		9	
2	33	0.8E	37		19	29		21	I					23		10	I					25		39										25		9	
3	36	3.6E	35		13	27		12	I					22		5	I					20		11										24		4	
4	42	2.9E	37		19	30		25	I					22		5	I					20		11										26		13	
355	42	2.6E	35		13	28		17	I+					23		10	I					21		17										25		9	
6	51	3.1E	38		23	27		12	I					24		14	I					22		22										28		22	I
7	63	8.8W	33		6	25		4	I+					28		33	I+					19		6	I									26		12	I
8	10	8.8E	31		0	23								20								18		0										23		0	
9	11	6.4W	31		0	23								20								17												22			
360	59	3.3E	36		16	26		8	I					23		10	I					22		22										29		26	

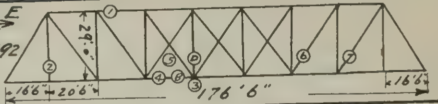
Deflections on E Girder

Records of little value. Instrumental vibration too large.

TABLE 6—11.

Byron, Ill. Skew, Through, Pin-Connected, Open Floor, Single Track
C. M. & St. P. Truss. Span 176' 6."

Train Headed E
Bridge #12
Records 361-392
Engine 1703
Date 9-12-07



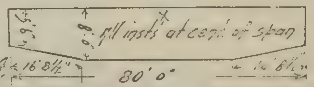
Train:- Engine #1703. Class 4-6-0. Kind:- Compound (Bald.) Cars:- 3 Loaded & Caboose.

Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			4th Pl. Post			Top Chord 3rd Pl. Inside Top				Hip Vertical Inside West				Floor Beam 4th Pl Point West Flange				Bottom Chord 4th Panel Outside Bar				South Stringer 4th Panel South Edge				Diagonal 3rd Panel Inside Bar				Main Diagonal Inside Bar				Bottom Chord 4th Panel Inside Bar			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
361	18		163	163	0	41	40	2		36	33	9		48	48	0		19	19	0		45	40	12	I	62	58	7	M	69	57	21	I	44	38	16	I
2	15		172		6	40		0	I	34		3		51		6		22		16	M	47		18	I	60		3		61		7		38		0	I
3	17		171		5	40		0	I	35		6		52		8		21		11		48		20		62		7	M	60		5	I	40		5	M
4	16		170		4	42		5		34		3		50		4		22		16		45		12	I	60		3	M	58		2		40		5	I
365	19		170		4	43		8	I	36		9		49		2		20		5		45		12	I	60		3	M	59		4	I	40		5	M
6	19		170		4	41		2	I	34		3		50		4		19		0		45		12	I	62		7	M	57		0	I	40		3	I
7	16		165		1	41	39	5	I	35		6		49		2		21		11		48		20	I	57	57	0	M	58	56	4		39		3	I
8	22		177		9	42		8	I	36		9		53		10		25		32		50		25										48		26	I
9	28		186		14	46		18	I	36		9		59		23		23		21	M	50		25	I	63		10	I					40	37	8	I
370	31		180	162	11	46		18	I	36		9		64		33		24		26	M	57		42	I	62		9	I	62		11	I	40		8	M
1	32		175		8	44		13		35		6		67		40		24		26		54		35	I	60		5	M	60		7	I	43		16	I
2	36		174		7	44		13	I	35		6		65		35		25	18	39	M+	57		42	I	69		21		60		7		40		8	I
3	34		176		9	44		13		36		9		65		35		24		33	M	57		42	I	64		12		58	55	5	I	40		8	M
4	11		162		0	38	38	0		34		3		50		4		20		11	M	42		5		57		0		57		2		36			
375	8					38		0						45				18		0		41		3		57	56	2		58		5		38		3	
6	40		183		13	45		18		40		21		66		42		23		28	M+	52		30	I	69		23		65		18		42		14	M
7	38		184		14	47		24		42		27		68		42		22		22	M	45		12	I	69		23		63		15		40		8	I
8	42		176		9	48		26	I	49		48		72		50		25		39	I+	35				66		18		69		25	I	47		27	
9	40		181		12	43		13		49		48		67		40		23		28	I	45		12	I	70		25		66		20	I				
380	47		180		11	47		24		43		30		57		19		30		67	M	45		12	I	64		14		65		18	I	45	36	25	I
1	12		157	153	3	37	37	0		33		0		49		2		20		11		40		0		56		0		60		9		37		3	M
2	11		156		2	40	40	0		33		0		49		2		18		0		43		8						52				38		6	I
3	15		153		0					33		0		48		0		20		11	M	40		0	I	54	55				54			36		0	I
4	16		158		3					35		6		51		6		18		0		38				57		4	I	60		11		37		3	I
385	17		155		1	39				34		3		53		10		16				40		0		55		0	I	58		7	I	35			I
6	20		155		1	39			I	35		6		52		8		18		0		42		5	I	56		2	M					35			I+
7	20		162		6	39			I	39		18		52		8		20		11		48		20						58		7		38		6	
8	24		164		7	40		0		31				53		10		19		6	I	45		12	I	64		16		60		11		36		0	I
9	21		161	152	6	42		5		33		0		54		12		25		39		46		15	I	55		0		58		7	I	36		0	
390	28		181		19	42		5		37		12		54		12		25		39	I	52		30	I	68		24		67		24		42		17	I
1	30		182		20	46		15		40		21		52		8		22		22		53		32	I	71		29		62		15		37		3	M
2	29		182		20	45		12		41		24		54		12		24		33		55		38	I	64		16	I	66		22		40		11	I

TABLE 6—O.

Davis Jct. Deck, Ballasted Floor, Single Track Plate Girder.
C. M. & St. P. Span 80'0".
Train:- Engine #1703. Class 4-6-0. Kind:- Compound (Baldwin). Cars:- 3 Loaded & Caboose.

Train headed E
Bridge #13
Records 393-404.
426-435
Engines 1703-304
Date 4-12-07

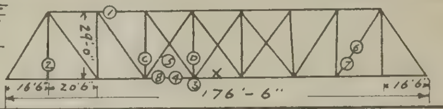


Instrument			Deflection			1				2	3				4	5				6				7	8
Location			1st Stiffener W. of Center South Girder			South Girder Inside Bottom					North Girder Inside Bottom					North Girder Outside Bottom				South Girder Outside Bottom					
No.	H.P.	C.B.	M	S	%E	M	S	%E	R		M	S	%E	R		M	S	%E	R	M	S	%E	R		
393	14		57	57	0													Out of adjustment		25	26				
4	13		57		0	17	17	0			14	14	0							26		0			
395	18		60		5	18		6			14		0							28		8			
6	25		63		10	20		18			16		14							30		15			
7	29		61		7	24		41	I		16		29							32		23			
8	28		60		5	24		41			18		14							34		31			
9	28		61	56	9	22		29	I		15		7							30		15			
400	31		63		12	24		41			16		14							33		27			
1	29		62		11	23		35	I		15		7							32		23			
2	26		62		11	21		24			17		21							32		23			
3	20		59		5	22		30			15		7							32		23			
4	16		55	55	0	18		6			14		0							29		12			
9-13-07 Eng. 304			Kind - Baldwin Compound Class 4-6-0 Train - 3 Loaded & Caboose			South Girder Outside Bottom					North Girder Outside Bottom					North Girder Inside Bottom				South Girder Inside Bottom					
426	17	4.4W	60	57	5	19	19	0								21	21	0		28	28	0			
7	20		60	57	5	19		0			23	23	0			20				28		0			
8	23	5.6W	60	57	5	20		5			24		4			21		0		28		0			
9	31	6.0W	63		11	21		10			22					23		10		29		4			
430	42	8.2W	65		12	24		26			28		22			24		14		31		11			
1	44	8.4E	70		23	28		47	I		32		39			26		24		33		18			
2	55	5.8E	81		42	33		74			33		43			31		48		39		36			
3	49	4.1E	78		37	32		68			32		39			26		74		38		36			
4	59	4.0W	78		37	31		63			31		122			37		76		37		32			
435	13	2.0W	54			20		5			24		4			22		5		26					

TABLE 6—p.

Byron, Ill. Skew, Through, Pin-connected, open Floor.
C.M. & St.P. Single Track Truss, Span 176'-6"
Train:—Engine #304. Class:- 4-6-0. Kind:- Compound (Bald.) Cars:- 3 Loaded & Caboose

Train Headed E
Bridge #12
Records 405-425
Engine 304
Date 9-13-07

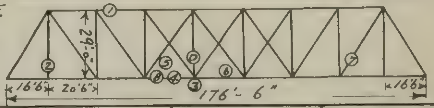


Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			4th Pl. Point			Top Chord 3rd Pl. Inside Top				Hip Vertical West Inside				Floor Beam, 4th Pl. Point West Flange				Bottom Chord 4th Pl. Inside Bar				South Stringer 4th Pl. South Edge —				Main Diagonal Outside Bar				Main Diagonal Inside Bar				Bottom Chord 4th Pl. Outside Bar			
NO	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
405	16	8.9W	160	155	3	30	29	3		37	37	0		40	40	0		40	35	14	I	42								54	54	0					
6	13	9.0W	170		10	33		14		36				40		0		38		9	I	43				34	34	0		57		6					
7	22	8.6E	165		6	33	28	18		44		19		53		32		35		0	I	45	45	0		35		3		61		13					
8	32	8.0E	162		5	35		25		42		14	I	53		32		37		6	I	56		25		35		3	I	56	53	6	M				I
9	30	7.1E	165	154	7	37	27	37	I	40		8	I	51		28		36		3	I+	56		25		35	33	6		56		6	I	24	24	0	I
410	47	4.8E	180		17	38		41		39		5		55		38		41	34	21	I	58		29	I	44		33		70		32		34		42	I
1	50	4.9E	176		14	37		37		38		3		52		30		39		15	I	56		25		40		21		74		40		33		38	I
2	49	4.3E	177	153	16	37		42		39		5		56		40		35		3	M	56		25	I	42		27		73	52	40		31		29	I
3	57	3.7E	174		14	33		27		43		16	I+	47		18		40		18	I	85		89		42	32	31		70		35		34		42	
4	57	3.9E	172	152	13	34		31		42		14	I	49		23		40		18	I	85		89		39		22		71		37		35		46	
415	59	4.2E	160	151	6	30	25	20	I	42		14	I	43		8		39	33	18	I	75		67		37		16		66		27		32	23	39	
6	50	5.9E	175	150	17					47		27		51		28						57		27	I	47		47		67	51	31		33		44	
7	51	6.4E	175	142	23					40		8	I+	52		30		43		30		72		60	I	50	31	61		71		39		33		44	
8	41^5	7.9E	172	141	22	30	24	25	I	43		16	I	51		28		37		12	I	63		40	I	40		29		65		27		35	22	59	
9	9	8.6W	140	140	0	23	23	0		38		3		40		0						45		0										22		0	
420	40	5.2E	162		16	30		30	I	43		76		53		32		38	32	19	M					43		39		61		20		30		36	I
1	35	4.5E	150	139	8	30	22	36	I	38		3		48		20		35		9	I	55		22	I	35		13		57	50	14		24		9	
2	37	3.5E	165	138	20	32		45	I	37		0	I	51		28		33		3	I	50		11	I	40	30	33	I	59		18		23		5	I
3	35	3.0E	152	137	11	27	21	29		39		5	I	49		23		33		3		56		25	I	34		13		54		8	I	23		5	
4	31	2.2E	160	136	18	28		33	I	40		8	I	54		35		35		6	M	45		0		35		17		55		10		24		9	
425	10	3.0E	135	133	0	19	20			38		3		40		0		32		0		44				27											

TABLE 6—q.

Byron, Ill. Skew, Through, Pin-Connected, Open Floor,
C.M. & St.P. Single Track Truss. Span 176'-6"
Train:- Engine 925 Class 4 4. 2. Kind:- Compound (Bald.) Cars:- 3 Loaded & Caboose

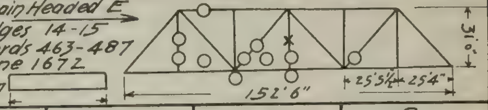
Train Headed E
Bridge #12
Records 436-462
Engine 925
Date 9-14-07



Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			4th Pl. Post			Top Chord 3rd Pl. Inside Top				Hip Vertical West Inside				Floor Beam 4th Pl. Point West Flange				Bottom Chord 4th Pl. Inside Bar				South Stringer 4th Pl. South Edge				South Stringer 5th Pl. South Edge				Main Diagonal Inside Bar				Bottom Chord 4th Pl. Outside Bar			
No.	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
436	11		158	154	3	37	36	3		22	24			40	35	14		32	32	0						35	34	3						24	26		
7	17		156		1	39		8		22				39		11		34		6		32	31	3	I	34		0		50	50	0	I	26		0	
8	22		156		1	38		6		25		4		40		14						39		26		40		18		48			M				
9	24					37		3		25		4		41		17						42		35	I	40		18		52		4	I				
440	30		159	153	4	38	35	9		27		12		45		29		35		9	M					43		26		52		4	I				
1	39		183		20	41		17		27		12		45		29	I	41		28	I					38		12						37		42	I
2	35		168		10	39		14		24		0		40		14		36		13	I	42		35	I	46		35	I	56	48	17	I	28		8	I
3	20		152	152	0	37		6						42		20										39		15		48		0	M	26		0	
4	34		168	147	14	38		9		28		17		48		37		38	31	23	M	40		29	I	49		44		55		15	I	28		8	I+
445	39		178	146	22	40	34	18		31		29	I	47		34		38		23	I	30								62		29		33	24	38	I
6	47		167	145	15	39		15		30		25	I	48		37	I	36		16	M+	44		42	I+	39		15	I	57		19	I	30		25	I
7	57		163	144	14	43		26		29		21		43		23	I	39		26	I	34		10		28			I+	55		15	M	33		38	I+
8	57		158	143	10	39		15		31		29	I	37		6	I	39		26	I	54		74	I+	44		29	I	55	46	20	I	30		25	I+
9	57		151	142	6	39		15		32		33	I	40		14	I	30			M	36		16	I+	36		6	I	51		11	I+	30		25	I+
450	52		168		18	42	33	27		34		42		47		34	I	37		19	M+	38		23		34		0	I	51		11	I+	30		25	I+
1	45		166		17	40		21		31		29																		55		20	I				
2	46		171	137	25	37		12		35		46		44		26		35		13	M+	50		61		48		41	I	60		30	I+	30	22	36	I
3	44		182		33	43		30		32		33		46		31	I	35		13	M+	46		48		48		41	I	63		37	I+	32		45	I+
4	44		183		34	42	32	31		28		17	I	53		51		40	30	33	M	43		39	I					58		26	I+	30		36	I+
455	39		174		27	41		28		26		8	I	44		26		38		27	M	36		16	I	48		41	I	52	44	18	I	26		18	I
6	35		150		10	35		9		28		17		37		6		35		17	M	38		23	I	39		15	I	51		16	I	25		14	I
7	14		137	136	1	33		3		25		4		33				33		10	I	34		10	I	34		0		42			M	22		0	I
8	40		155		14	35	31	13		27		12	I	42		20		40		33	M	34		10	I	45		32	I+					30		36	I
9	28		148		9	33		6		27		12		35		0		33		10	M					40		18	I	50		14	I	21			I
460	29		132		12	33		6		27		12		38		9		33		10	M	40		29	I	45		32		50		14	I	22		0	
1	21		136		0	28	30			27		12		38		9		30		0	M	45		45	I	38		12		45		2	M				
2	13		136		0	29				26		8		37		6		30		0	I	37		19									M	20	20	0	

Metz, Ia. Through, Riveted, Open Floor Truss. Single Track. Span 152'-6"
Rock Island.

Train Headed E →
Bridges 14-15
Records 463-487
Engine 1672



Train:- Engine # 1672. Class 2-8-0 Kind:- Simple. Cars:- Coach & Private Car. Date 9-16-07

Instrument			Deflection			1	2				3				4				5				6				7				8			
Location			Center of Truss Span			Diagonal 3rd Pl. Inside Bottom	Hip Vertical Inside West				Floor Beam Center Pl. Point West Flange				Diagonal 3rd Pl. Outside Top				So. Stringer 3rd Pl. Outside Flange				So. Stringer 2nd Pl. Outside Flange				Main Diagonal Inside Top				Top Chord 2nd Panel			
No.	M.P.H.	C.B.	M	S	%E		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
463	11	0.6W	106	102	4																						54	49	10					
4	13	0.6W	102		0		45	42	7		35	34	3						40	39	3						51		4		33	30	10	
465	18	0.9W	104		2		42		0	I	37		9						45		15	I					56		14		31		3	
6	20	1.1W	103		1		42		0	I	37		9						43		10	I					52		6		37		23	
7	24	1.6W	106	101	5		43		2	I	39		15						50		28						54		10		32		7	
8	34	2.2W	115		14		40			I	44		29	I					51		31		39	34	15	I	60		22		36		20	
9	37	2.7W	116	100	16		43		2	I	45		32	I					53		36	I	36		6	I	61		24		38		27	
470	43	3.0W	105		5		50		19	I	40		18	I					52		33	I	45		32	I	58		18		36		20	
1	53	1.4E	108	99	9						41		21	I					35			I	39		15	I	56		14		34		13	
2	35	4.2E	113	98	15						43		26	I									46		35	I	61		24		36		20	
3	44	3.8E	108	98	10																						55		12					
4	38	3.6E	112	97	15						43		26						50		28	I	45		32	I	56		14		35		17	
																							Hip Vertical Outside East											
475	42	3.3E	106	96	10						43		26	I	So. Plate Girder				54		38		17				53		8	I	35	29	20	
6	49	3.5E	100	96	4						40		18	I	½ mile West of				54		38	I	16				55		12		30		3	
															Truss Span Outside Bottom																			
477	53	4.8E	100	95	5						43		26	I					45		15	I	15	15	0		57		16		30		3	
8	57	7.9E	100	94	6						44		29	I					45		15	I	12				56		14		30		3	
9	53	6.5W	100	93	8						41		21	I	46	45	2	I	43		10	I	15		0	I	53		8		29		0	
480	55	7.5W	108	102	6						42		24		53		18		49		26	I	16		7	I	58		18	I	35		20	
1	44	7.1W	110		8						42		24	I	47		4	I	53		36	I	14			I	56		14		35		20	
2	43	7.3W	117		15						46		35		50		11	I	50		28	I	15		0		57		16		36		23	
3	35	7.7W	113	101	12						47		38		53		18	I	57		46	I	15		0	I	61		24		33		13	
4	34	8.0E	113		12						42		24		45		0		52		33	I	15		0		59		24		32		10	
485	31		114		13						38		12						48		23		17		13		61		24		30		3	
6	25	7.5E	105	100	5						36		6						40		3	I	17		13		52		6		30		3	
7	13	7.7E	100		0						30								40		3						50		2		30		3	

TABLE 6—S.

Metz, Io
Rock Island

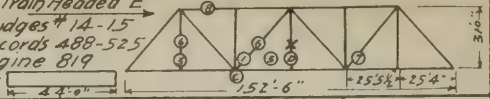
Through, Riveted, Open Floor Truss, Single Track, Span 152'6"

Deck Plate Girder, Open Floor, Single Track. Span 44'0"

Train:-Engine 819 Class 4-6-2 Kind:-Simple. Cars:- Coach & Private Car

Date 9-17-07

Train Headed E
Bridges # 14-15
Records 488-525
Engine 819



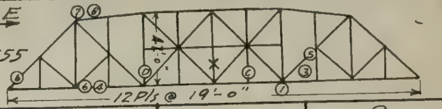
Instrument			Deflection			1						2	3				4				5				6						7				8			
Location			Center of Truss Span			Diagonal 3rd Pl Inside Bottom							Hip Vertical Inside West				So. Pl. Girder Outside Bottom				South Stringer 3rd Pl. Outside Flange				Diagonal 3rd Pl. Outside Top						Main Diagonal Inside Top				Top Chord 2nd Panel			
						Tens			Comp.																Tens			Comp.										
No	MPH	C.B	M	S	%E	M	S	%E	M	S	%E		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R
488	11	3.2E	102	100	2	22	22	0	25				26	27							28	28	0		9	9	0	26			47	45	4		27	27	0	
9	13	2.9E	103		3	22		0	23				26								29		4		10		11	25			49		9		28		4	
490	18	2.3E	105		5	22		0	26				29		7						28		0	I	12		33	25			49		9		27		0	
1	22	1.4E	102	99	3	22		0	29				30		11						29		4	I	9		0	28			48		7		28		4	
2	26	0.3E	104		5	22		0	27				30		11						31		11	I	10		11	28			48		7		25			
3	28	0.9W	105		6	22		0	26				29		7						33		18	I	12		33	27			52		16		27		0	
4	34	2.3W	108	98	10	23	21	10	30				30		11						35		25	I	12		33	26							26			
495	35	4.3W	109		11	24		14	28				30		11		32	30	7		44		57		9		0	30			54		20		29		7	
6	37	6.5W	108		10	25		19	27				29		7		32		7		42		50	I	10		11	29							29		7	
7	44	7.1E	109	97	12	26		24	29				36		33		33		10	I	38		36	I	10		11	29			52		16		32		19	
8	46	2.6E	111		14	25		19	27				35		30	I	34		13		37		32		11		22	27			42				30		11	
9	50	2.3W	101		4	27		29	26				32		19		33		10	I	37		32	I	12		33	27			49		9		33		22	
500	57	6.8W	103	96	7	28		33	25				34		26	I	35		17	I	40		43	I	9		0	28			50		11	I	31		15	
1	57	5.9E	101		5	23		10	24				34		26	I	32		7	I	31		11	I	10		11	27			51		13	I	28		4	
2	63	0.6E	96	95	1	22		5	26				29		7	I	33		10	I	31		11	I	13		44	26			50		11	I	27		0	
																									Hip Vertical East Inside													
503	63	6.6W	100		5	25	20	25	27				30		11		34		13	I	33		18	I		39					48		7	I	30		11	
4	53	8.6E	99	94	5	25		25	24				34		26	I	37		23	I	35		25	I	50		28	I			48		7	I	32		19	
505	49	3.6E	106		13	25		25	24				34		26		35		17	I	33		18	I	45		15	I			48	44	9	I	30		15	
6	44	0.4W	100	93	8	23		15	27				34		26	I	30		0		35		25	I	49		26	I			52		18		31		19	
7	46	6.0W	106	92	15	27		35	25				36		33		32		7		40		43	I	46		18	I			54		23		33		27	
8	43	4.9E	111		21	22		10	25				34		33						35		25	I	43		10	I			52		18		31		19	
9	37	3.9W	103	91	13	22		10	24				32		19		30		0		36		29	I	42		8	I			53		20		33		27	
510	40	6.9E	102		12	22		10	24				32		19		35		17	I	36		29	I	39		0	I			50		14		33		27	
1	37	1.4E	102	90	13	21		5	27				33		22		31		3		35		25	I	43		10	I			50		14		32		23	
2.	18	0.7E	90		0	20		0	20				27		0		29				28		0	I	39		0				46		4		26		0	
			Center of South Girder			Pl. Gird Span So. Girder N. Bottom																																
513	21	2.1W	42	43		35	37						29		7		33		10		31		11	I	41		8				45		2		29		12	
4	33	4.5W	44		2	40		8	I				32		19		30		0		40		43	I	40		3	I			46		5		25			
515	38	8.2W	44		2	43		16	I				31		15		34		13		45		61	I	42		8	I			49		11		27		4	
6	34	8.6E	44		2	41		11					30		11	I	31		3												46		5		26		0	
7	40	5.7E	45		5	41		11	I				31		15	I	33		10		35		25	I	43		10				51		16		33		27	
8	44	2.5E	45		5	40		8					34		26	I	32		7		32		14	I	43		10	I			50		14		29		12	
9	50	5.6E	48	42	14	39		5	I				30		11	I	35		17	I	33		18	I	43		10	I			50		14	I	32		23	
520	53	2.5E	46		10	41		11	I+				28		4	I	34		13	I	31		11	I	51		31	I			50		14		32		23	I
1	55	0.4W	46		10	41		11	I+				29		7		34		13	I	35		25	I	55		41	I							34		31	
2	60	4.8W	51		21	39		5	I				32		19	I	35		17	I	35		25	I	46		18	I			47		7	I	30		15	
3	61	8.2E	48		14	42		14					31		15	I	35		17	I	35		25	I	45		15	I			45		2	I	30		15	
4	39	6.2E	45		7	43		16	I				32		19		33		10		34		21	I	42		8	I			50		14		30		15	
525	20	5.0E	43		2	38		3					28		4		30		0		28		0	I	40		3				43				27		4	

TABLE 6—t.

Ft. Wayne, Ind. Through, Pin-Connected, Open Floor, Curved Top Chord,
Nickel Plate. Semi-Divided Panels, Single Track Truss. Span 228' 0"

Train:- Engine 147. Class 2-8-0. Kind:- Simple. Cars:- 4 Loaded.

Train Headed E
Bridge # 16
Records 526-555
Engine 147
Date 9-19-07



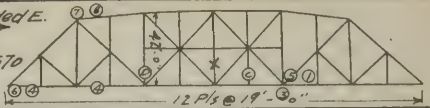
Instrument			Deflection			1				2	3				4				5				6				7				8			
Location			4th Pl. Point			Floor Beam, 8th Pl. Point East Flange					South Stringer 9th Pl. Outside Flange				Bottom Chord 3rd Pl Outside Bar				Main Diagonal 9th Pl. Inside Bar				Bottom Chord 3rd Pl Inside Bar				Top Chord 3rd Pl. Inside Top				Top Chord 3rd Pl Outside Top			
526	12	4.8W	200	190	5	52	52	0							40	40	0		62	60	3		31	34			39	39	0		36	36	0	
7	13	5.2W	204		7	57		10							40		0	M	66		10		32			I	42		8		36		0	
8	18	5.8W	191		1	57		10											62		3		37		9		39		0		34			
9	22	7.2W	195	189	3	58		12			55	53	4	I	43		8	M	66		10	I	35		3	I	41		5		36		0	
530	29	7.5E	203		7	57		10	I		54		2	I	45		13	M	64		7	I	40		18	I	44		13	I	37		3	
1	29	5.8E	200		6	63		21	I		56		6	I	42		5	M	64		7	I	38		12	I	42		8	I	40		11	
2	32	4.5E	197		4	56		8	I		58		9	I	46		15	M	66		10	I	39		15	I	42		8	I	40		11	I
3	35	2.4E	195	188	4	58		12	I		50			I	44		10	M	66		10	I	39		15	I	42		8	I	40		11	
4	4.4	0.0	191		2						64		21	I	43		8	M I	62		3	I	37		9	I	42		8	I	39		8	I
535	51	1.8W	193		3	55		6	I+		62		17	I	43		8	M I	61	59	3	I	35		3	I	42		8	I	45		25	I
6	39	2.2W	192		2	52		0	I+		67		26	I	43		8	M I	64		8	I	34		0	I	38			I	38		6	
7	38	4.2W	189	187	1	54		4	I		64		21	I+	43		8	I	61		3	I	36		6	I	44		13	I	40		11	
8	42	3.6W	185			52		0	I		63		19	I+	40		0	M I	60		2	I	35		3	I	38				38		6	I
9	14	4.2W	184			59		13			50				41		3	M	66		12		35		3	I	42		8	I	36		0	
540	10	4.1W	174			56		8			53		0		47		18		57				35		3		38				34			
1	29	6.6W	200	186	8	56		8	I		54		2	I	46		15	M					40		18	I					45		25	
2	29	7.6E	199		7	63		21	I		54		2	I	46		15	M	63		7	I	37		9	I					40		11	
3	33	6.7E	195		5	66		27	I						45		13	M I	65		10	I	35		3	I	43		10		41		14	
4	38	4.6E	195		5	54		4	I		58		9	I+	45		13	M	63		7	I	38		12	I	43		10		41		14	
																							End Post Outside Bottom											
545	28	4.8E	197	185	6	66		27	I		47			I	44		10	I+	63	58	9	I					42		8		39		8	
6	29	4.1E	195		5	65		25	I		52			I	43		8	M	64		10	I	33	24	38		43		10		39		8	
7	24	2.8E	195		5	53		2	I		59		11	I	45		13	M I	69		19		32		33						36		0	
8	23	2.0E	193		4	54		4	I		57		8	I	44		10	M I	65		12	I					40		3		40		11	
9	25	0.4E	198	184	8	52		0	I		67		26	I	45		13	M	70		21	I	30		25		42		8		45		25	
550	48	0.8E	192		4	60		15	I+		70		32	I+	45		13	M I	67		16	I	25		4		42		8	I	44		22	I
1	13	4.1E	188		2	53		2			60		13		43		8	M	60		3		28		16		38				32			
2	40	6.5E	188		2	53		2	I		58		9	I				M I	63		9		25		4	I	39		0	I	36		0	I
3	44	0.8E	185	183	1	60		15	I		61		15	I				M I	58		0		24		0		41		5	I	38		6	I
4	28	5.5E	188		3	59		13	I		59		11	I				M I	59		2	I	24		0		41		5	I	42		17	
555	23	4.7E	182	182	0	63		21	I		60		13	I				M I	60		3	I	24		0		38				36		0	

TABLE 6—u.

Ft. Wayne, Ind. Through, Pin Connected, Open Floor, Curved Top chord,
Nickel Plate. Semi-Divided Panels. Single Track Truss. Span 228'-0"

Train:- Engine 185. Class 4-6-0. Kind:- Simple. Cars:- 4 Loaded.

Engine Headed E.
Bridge #16
Records 556-570
Engine 185
Date 9-20-07



Instrument			Deflection			1				2				3				4				5				6				7				8			
Location			4th Pl. Point			So. Stringer 9th Pl. Outside Flange								Floor Beam 8th Pl. Point East Flange —				Bottom Chord 3rd Pl Outside Bar				Main Diagonal 9th Pl Inside Bar				West End Post Outside Bottom				Top Chord 3rd Pl Inside Top				Top Chord 3rd Pl Outside Top			
No	MPH	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
556	9	0.8W	200	200	0	48	48	0										42	42	0						35	35	0		39	38	3					
7	19	2.2W	203		2	51		6	I									45		7		63	63	0		34				40		5		36	37		
8	21	4.0W	200		0									37	34	9		46		10	I	67		6		33				38		0					
9	29	6.6W	205		2	58		21						36		6		45		7	I	69		10		36		3		43		13					
560	27	8.8W	210		5	57		19	I					41		21		44		5	I	64		2		35		0		43		13		45		22	
1	28	7.8E	215		8	51		6	I					40		18		43	40	8	I	70		11	I	44		26		41		8		41		11	I
2	35	5.0E	216		8	55		15	I					41		21		43		8	I	75		19		42		20		45		18		41		11	
3	35	0.8E	205		2	53		10	I					37		9	I	46		15	I	74		17	I	42		20		43		13		40		8	I
4	45	2.6W	202		1	63		31	I					40		18		48		20	I	73		16	I	38		9	I	42		10	I	41		11	
565	45	5.6W	196	196	0	65		35	I					35		3		46		15	I	78		24		35		0		42		10	I	40		8	
6	37	8.0W	212	192	10	55		15	I					41		21		46	38	21	I	71		13	I	40		14		42		10		43		16	
7	43	6.7E	202		5	54		12	I					38		12	I	47		24	I	71		13	I	39		11	I	43		13	I	42		14	I
8	50	3.8E	206		7	59		23	I					39		15	I	47		24	I	66		5	I	40		14	I	41		8	I	41		11	I
9	34	2.0E	206		7	49		2	I					37		9		42		11	I	60				40		14		43		13		42		14	
570	33	1.0E	206	182	13	53		10	I					41		21		38		0	I	69		10		38		9		43		13		44		19	

Bridge #16
Records 571-586
Engine 181
Date 9-20-07

Train:- Engine 181. Class 4-4-0. Kind:- Simple. Cars:- 4 Loaded.

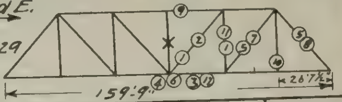
																										W. End Floor Beam W. Bottom Flange											
571	12	6.6W	182	184		43	44							24	24	0		34	34	0		61	56	9						38	38	0		40	36	11	
2	15	7.1W	188		2	48		9						29		21		38		12		57		2						38		0		38		6	
																		W End Floor Beam E. Bottom Flange																			
3	20	7.6E	185	183	1	42								32		33		41	31	32		56		0						39		3		36		0	
4	24	3.9E	188	182	3	56		27						32		33						60		7		18	18	0		38		0		35			
575	30	2.2W	188		3	43			I					32		33		40		29		68		21		18		0		42		11		36		0	
6	32	7.1W	188		4	50		14	I					36		50	I	37		19		62		11		20		11		40		5		38		6	
7	41	2.9E	186	180	3	47		7	I					32		33	I	37		19		64		14		16				42		11	I	40		11	I
8	41	2.2W	179	179	0	47		7	I									36		16		64		14		17				39		3	I	37		3	
9	33	5.6W	190	178	7	49		11	I					28		17		32		3		61		9		20		11		38		0		37		3	
580	36	6.9E	184	177	4	49		11	I					25		46	I	33		6		60		7		18		0		38		0	I	37		3	
1	11	6.9E	183	176	4	42								24		0		30				56		0		18		0		40		5		31			
2	40		182	175	4	45		2	I					28		17		32		3		56		0		16				42		11	I	37		3	
3	50	1.2W	192	174	10	56		27	I					39		29	I	43		39		57		2		20		11		40		5	I	39		8	I
4	38	2.5W	179	173	3	48		9	I					32		33		34		10		58		4	I	16				38		0	I	38		11	
585	59	8.8E	209	172	23	53		20	I					33		38		39		16	I	56		0	I	20		11		44		16	I	41		14	I
6	32	1.2E	184	172	7	50		14	I					27		12		37		19		55			I	18		0		38		0		38		11	

TABLE 6—v.

Byron, Ill Skew, Through, Riveted, Single Track, Open Floor. Span 159'9"
C.M.&St.P.

Train Headed E.

Bridge #17
Records 600-629
Engine 263
Date 7-14-08.



Train:-Engine #263. Class 4-6-0. Kind:- Simple. Cars:- 3 Loaded & Caboose.

Instrument Location			Deflection			1				2				3			
			Middle Vertical So. Truss			Diagonal 4th Pl. Top Outs.				Diagonal 4th Pl. Top Ins.				N. Stringer 4th Pl. Outs. Bottom			
No.	M.P.H.	C.B.	M	S	%E.	M	S	%E	R	M	S	%E	R	M	S	%E	R
600	13		93	91	2	41	38	8		40	38	5					
1	20		93		2	42		10		42		10	I	26	22	18	
2	22		93	90	3	45		18	I	40		5	I				
3	27		98		9	43		13		41		8	I				
4	34		98	89	10	42	37	14		42	37	14	I	20			I
605	32		97		9	42		14		41		11	I	20			
6	56					48		30	I	49		32	I				
7	59		103	88	17	48		30		46		24	I				
608	42		95	87	9	42	36	17	I	42	36	17	I	25		14	
9	43.5		97	86	13	41		14		42		17		31		41	
610	44.5		99	85	16	47		31		44		22	I	34		55	I
1	52		93		9									41		86	
2	16		85	84	1	36	35	3		34	35			22		0	
3	28		90		7	37		6	I	38		9	I	29		32	I
4	36		87	83	5	36		3		39		11	I	29		32	I
615	43.5		92		11	45		29		40		14	I	39		97	
6	51		97		17	51	34	50		45	34	32		47		114	
617	38	3.3W	87	82	6	42		24		38		12	I	30		36	
8	40	4.2W	87		6	39		15		42		24	I	30		36	
9	61	5.9W	97		18	46	33	39	I	48	33	45	I	44		100	
						4th Pl. Post East Outs											
620	51	2.7W	106	92	15	32	28		I	45		36	I	41		86	
1	53	2.8W	104		13	34			I	47		42		49		123	
2	51	2.4W	102	91	12	34				45		36		48		118	
3	48	2.5W	106		16	35				47		42		44		100	
4	41	2.8W	95		4	36				40	32	8	I	32		45	I
625	26	2.8W	92	90	2	36				38		3	I	28		27	
6	45	4.8W	95		6	36				41		13	I	32		45	I
7	59	5.9W	106		18	38			I	44		19		40		82	
8	51	6.1W	106	89	19	36				44		19	I	37		68	
9	11	4.9W	88	88	0					35		9		22		0	

No.	4				5				6				7			
	Floor Beam Cent. Pl. Point W. Bottom				Main Diag. Outs. Bar				Floor Beam Cent. Pl. Point E. Bottom				Main Diag. Ins. Bar			
	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
600	19	18	6		42	41	0		26	23	13		48	44	9	I
1	20		11						30		30					
2					45		7						47		7	I
3																
4	19		6	I	47		12	I	30		30	I	48		9	I
605	18		0	I	45		7		29		26	I	47		7	I
6	21		17	I	53		26		32		39	I	57		30	I
7	23		28	I	53		26		30		30	I	59		34	I
					Main Diag. Ins. Bar								Main Diag. Outs Bar			
608	25		39	I	52	44	18		30		30	I	45	40	13	I
9	25		39	I	57		30		30		30	I	43		7	I
610	25		39	I	51		16		33		43	I	48		20	I
1	26		44	I	57		30	I	30		30	I	53		32	
2	19		6		43			I	24		4		40		0	
3	18		0	I	44		0	I	25		9	I	40		0	
4	22		22		50		14		29		26	I	41		3	
615	27		50		52		18	I	33		43					
6	26		44	I	53		20		30		30	I	47		18	
					End Post Top Ins.											
617	22		22		31	31	0		29		26	I	43		8	
8	22		22		30				29		26	I	43		8	
9	25		39	I	35		13		29		26	I	43		8	I
620	26		44		44		42		32		39		49		22	
1	24		33	I	45		45		30		30	I	51		30	
2	26		44		43		39		30		30	I	51		30	
3	28		55		40		29		29		26	I	49		22	
4	22		22		35		13		29		26	I	43		8	
625	18		0		35		13		28		22		40		0	
6	24		33	I	33		6		35		52	I	45		13	
7	23		28	I	40		29		33		43		49		22	
8	24		33	I	40		29		35		52	I	45		13	
9	18		0		32		3		24		4		40		0	

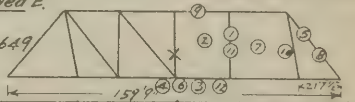
No.	8				9				10				11						12			
	End Post Ins. Bottom				Top Chord 4th Pl. Ins. Top				End Hip. Vert. Ins. E Edge				4th Pl. Post E. Inside						So. Stringer 4th Pl. Outs. Bottom			
													Com.			Tens						
	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R
600	35	32	9		39	37	5		44	41	5		18	18	0	11			28	22	27	
1					37		0	I											30		36	I
2	35		9		38		3	I	53		26	I	22		22	14						
3					39		5															
4	32		0		37		0	I	48		14	I	22		22	15						
605	32		0		38		3	I	53		26	I	17			15			35		59	
6	37		16		43		16	I	62		47	I+	24		33	22						
7	37		16		44		19	I	59		40	I							25		14	
608	35		9		39	36	8	I	53		26	I	22		22	13			39		77	
9	34		6		37		3	I	57		36	I	22		22	15			37		68	I
610	38		19		40		11	I	58		38	I	26		44	20			33		50	
1	42		31		42		17		58		38	I	24		33	22			32		46	
2	31	31	0		33				43		2	I	19	17	12	8			23		5	
3	37		19		32			I	48		14	I	21		24	9			30		36	I
4	36		16		39		8	I	54		29	I	18		6	13			40		82	
615	35		13		40		11	I	53		26	I	21		24	17			35		59	
6	40		29		37	35	6		55		31	I+	28		65	19			35		59	
617	35		13		39		11		57		36	I	18		6	13			30		36	I
8	34		10		37		6		54		29	I	19		12	14			35		59	
9	38		23		39		11		56		33	I	23		35	13			32		46	
620	40	30	33		44		26		57		36		23	16	44	16			38		73	
1	43		43		43		23	I	57		36	I+	24		50	15			28		27	I
2	41		37		40		14	I	61		45	I+	20		25	19			37		68	
3	39		30		42	34	14	I	62		48	I+	23		44	14			35		59	I
4	35		17		37		9	I	57		36	I	16		0	17			35		59	
625	35		17		34		0		44		5	I	17		6	11			28		27	I
6	35		17		35		3		49		17	I	26		25	12			33		50	
7	41		37		38		12		57		36	I+	20		25	19			35		59	I
8	37		23		44		29		57		36	I+	22		37	22			32		46	I
9	29				34		0		42		0		16		0	3			27		23	

TABLE 6—W.

Byron, Ill. Skew, Through, Riveted, Single Track, Open Floor. Span 159′ 9″
C. M. & St. P.

Train:- Engine #939. Class 4-4-2 Kind:- Compound. Cars:- 3 Loaded & Caboose.

Train Headed E.
Bridge # 17
Records 630-649
Engine 939
Date 7-15-08.



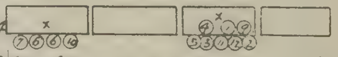
Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11						12					
Location			Mid. Vertical So. Truss			4th Pl. Post E. Outside				Diagonal 4th Pl. Ins. Top				N. Stringer 4th Pl. Outs Bottom				Floor Beam Cent Pl. Pnt W. Bottom				End Post Ins. Top				Floor Beam Cent. Pl. Point E Bottom				Main Diag. Outs. Bar				End Post Ins Bottom				Top Chord 4th Pl. Ins. Top				E. Hip Vert. Ins East				4th Pl. Post Ins. East						So. Stringer 4th Pl. Outs Bottom					
																																														Comp.			Tens.			Eng			Car		
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	E	M	S	E
630	Slow	4.1E				29	29	0		35	34	3		21	21	0		19	17	12						24	21	14		42	42	0										41	41	0					10								
1	13	3.5E	92	92	0	32		10		37		9		21		0	I	17		0		37	32	16		25		19		42		0		34	32	6		38	34	12		43		5		16	16	0	12			[illegible]		[illegible]	[illegible]		[illegible]
2	21		96		4	37		28		36		6	I	22		5	I	18		6		35		9		26		24		45		7		35		9		39		15		43		5	I	21		31	13			[illegible]		[illegible]	[illegible]		[illegible]
3	28	3.7W	95		3	36		24		36		6	I	22		5	I	20		18	I	34		6		26		24	I	45		7		34		6		39		15	I	45		10	I	17		6	15			[illegible]		[illegible]	[illegible]		53
4	30	4.9W	95	91	4	44		17		36		6	I	21		0		17		0	I	37		16		26		24		48		13		36		12		36		6		44		12	I	[illegible]		0	17			28		45	26		53
635	35	9.4W	101		11	37		28		37		9	I	23		10	I	15			I	39	31	26		27		29	I	[illegible]		10		39	31	26		39		13	I	[illegible]		[illegible]	I	[illegible]		[illegible]	17			23		28	22		24
6	41½	10.2E	98		8	36	28	29		38	33	15	I	20				16			I	35		13		27		29	I	[illegible]		12	I	35		13		37	32	28	I	[illegible]		[illegible]	I	[illegible]		[illegible]	[illegible]			28		56	26		[illegible]
7	59	5.5E	100	90	11	36		29		48		46	I	35		67	I	20		18	I	36		16		31		48		[illegible]	[illegible]	22	I	38		23		38		19		52		27	[illegible]	21		31	13			20		11	[illegible]		[illegible]
8	66	6.6W	105		17	32		14	I	41		24	I	30		45	I	18		6	I	35	30	17		33		67	I	42		5	I	39	30	30		39		22		49		20	I	[illegible]		[illegible]	14			27		50	[illegible]		[illegible]
9	62	9.3E	95	88	8	37		32	I	45		36	I	30		43	I	18		6	I	35		17		30		43	I	48		20	I	36		20		37		16	I	53		29	I	21		[illegible]	[illegible]			25		[illegible]	[illegible]		[illegible]
640	47	1.9E				37		32	I	39		18	I	27		29	I	21		24	I	37		23		28		33	I	47		18	I	38		27	I	39		22		47		15	I	21		31	[illegible]			27		[illegible]	21		[illegible]
1	51	4.2W	98	87	13	36	27	33		39		18	I					21		24	I	35		17		28		33	I	46		15	I	38		27	I	37	30	23		54		32	I	14		19	20			20		11	26		[illegible]
2	21	10.7W	82	80	3	32		18		29			I	21		0	I	19		12		35	29	21		25		19	I	41		2	I	32	29	10		32		7					I	18		12	8			30		67	23		[illegible]
3	40	5.5E	92		15	33		22		35	32	8	I	25		19	I	20		18	I	32		10		26		24	I	42		5	I	34		17		34		14	I	47		15	I	18		12	13			30		67	23		[illegible]
4	42	2.8E	91		14	30		11		36		12	I	29		38	I	20		18	I	39		34		26		24	I	40	38	5	I	32		10		32		7	I	43		5	I	21		31	10			30		67	17		0
645	46	0.3W	94		18	29	26	12		36		12	I					25		47	I	37	28	32		27		29	I	47		24	I	37	28	29		36		20	I	52		27	I	20		25	9			23		28	23		[illegible]
6	46½	2.8W	97	79	23	31		19	I	36		12	I	29		38	I	24		41	I	35		25		27		29	I	48		26	I	34		21		38		27	I	48		17	I	17		6	12			20		11	23		35
7	57	7.8E	92		16	36		38		40		25	I	32		52	I	19		12	I	35		25		30		43	I	47		24	I	34		21		36		20	I	51		24	I	18		12	12			19		6	20		18
8	22	10.8E	85		8	34		31		32		0		23		10	I	19		12		32		14		24		14		31		8		32		14		28	28	0		44		7		18		12	9			21		17	18		6
9	52	7.3W	92	78	18	33		27	I	35		9	I	31		48		23		35	I	32		14		32		52	I	45		18	I	33		18		35		25		54		32	I	16		0	17			21		17	22		29

TABLE 6—x.

Davis Junct. Ill.
C.M.&St.P.

Deck, Ballasted Floor, Single Track, Plate Girders. Span 80'0".

Train Headed E. →
Bridge #13
Records 650-664
Engine 939



Train:- Engine #939. Class 4. 4.2. Kind:- Compound. Cars:- 3 Loaded & Caboose. Date 7-16-08. ← 4 Spans @ 80'0" →

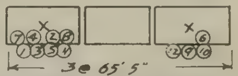
Instrument				Deflection			1				2				3				4				5						6				7				8				9				10				11				12			
Location				Center. South Girder West Span			3rd span N. Gird. N. Pair Outs Bottom				3rd span. N. Gird S Pair Ins Bottom				3rd span S Gird S. Pair Ins. Bottom				3rd span N. Gird S. Pair Outs Bottom				3rd span S Gird S Pair Outs Bottom						West Span N. Girder Outs Bottom				West Span So Girder Outs Bottom				West Span So Girder Ins Bottom				3rd Span. N. Gird. N Pair Ins Bottom				West Span N. Girder Ins Bottom				3rd Span S Gird N Pair Outs. Bottom				3rd Span S Gird N Pair Ins Bottom			
																							Eng.			Car																												
No	MPH	C. Bal		M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
650	20	11E	7.6E	59	58	2					36	33	9		16	16	0						28	28	0	24	23	4	16	16	0		32	24	10		29	29	0						19	16	19			22			23	18	28	
1	21	13W	5.2E	59		2	37	32	16	I	33		0	I	16		0		25	23	9		31		11	24		4	17		6		29		0		28								17		6						19		6	
2	35	3.2E	9.7E	58	52	2	38		19		37		12		18		12		30		30		35		25	27		13	17		6		29		0		31		7						18		12		24		9		23		28	
3	40	2.6W	3.7E	68	56	21	36		12	I	35		6	I	20		25		5		9	I	39		39	23		0	22		38		32		10		32		10		32	30	7		20		25		27		23		24		33	
4	66	4.5E	1.0E	68	55	24	42		31	I	36	32	12	I	24		50		37		17	I	32		14	40		14	24		50		36		24		36		24		33		10		24		50		26		18	I	25		39	
655	40	4.4E	10.5E	63	54	17	32		0	I	34		6	I	19		19		28		22		36	27	33	26		13	19		19		31	28	11		35		21		27				24		50		25	21	19	I	26		44	
6	59	2.4W	2.1E	67		24	44	31	42	I	44		38		25	15	67		38		65	I	44		48	37		61	24		50	I	32		14	I	32		10		40		33	I	25		56	I	25		19	I	26		44	
7	49	5.0E	10.5	63	53	19	36		16	I	33		3	I	20		33		31		35	I	32		19	29		26	23	15	53	I	34		21		34		17		34		13	I	25		56	I	29		38	I	27	17	59	
8	62	4.6W	.9E	67		26	43		39	I	44		38		26		72		40	22	82	I	38		41	36		56	20		33		31		11		32	28	14		39		30	I	20		25		24		14	I	25		47	
9	62	5.2E	10.3 W	67		26	40		29	I	38	31	22	I	23		53	I	35		59	I	30	26	15	35		52	23		53	I	37		32		35		25		32	29	10	I	21	15	40		24		14	I	24		41	
660	66	2.1E	8.6E	64	52	23	43		39	I	40		29	I									35		35	26		13	20		33	I	34	27	26						38		31	I	24		60		29	20	45		29		71	
1	70	4.9W	1.6E	61		17	48	30	60		42		36		25		67	I	42		91		40		54	24		4	22		47	I	35		30		41		46		41		42		25		67		28		40					
2	50	7.9F	7.6W	67	51	31	37		23	I	34		10	I	22		47	I	30		36		31		19	29		26	20		33		34		26		35		25		38		31	I	24		60		28		40		25		47	
3	59	12.4E	3.1W	70		37	41		40	I	40		29	I	23		53	I	35		59		30		15	35		52	24		60	I	39		44		40		43		36		24	I	22		47		24		20		24		41	
4	20			52		2	32		7		30	30	0						22		0		28		8	23		0	16		7		29		7		29		4		29		0		16		7						17		0	
		3rd Span	West Span																																																					

TABLE 6—y.

Bardwell, Wis. Deck, Open Floor, Single Track, Plate Girders. Span 65'-5"
C. M. & St. P.

Train:- Engine #263. Class 4-6-0. Kind:- Simple. Cars:- 1 Loaded & Caboose.

Train Headed West.
Bridge #19
Records 665-676.
Engine #263
Date 7-18-08.



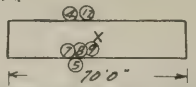
Instrument				Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location				Center So. Girder West Span			S. Gird. W. Span 1/4 Point Outs. Bottom				N. Gird. W. Span Center Ins. Bottom				S. Gird. W. Span Center Ins. Bottom				N. Gird. W. Span 1/4 Point Outs. Bottom				S. Gird. W. Span Center Outs. Bottom				N. Gird. E. Span Center Ins. Bottom				N. Gird. W. Span 1/4 Point Ins. Bottom				S. Gird. W. Span 1/4 Point Ins. Bottom				N. Gird. E. Span Center Outs. Bottom				S. Gird. E. Span Center Outs. Bottom				N. Gird. W. Span Center Outs. Bottom				S. Gird. E. Span Center Ins. Bottom			
No.	MPH	C. Bal		M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
665	20	1.7W	7.5W	75	73	3	35	30	17		34	32	6		27	25	8		32	27	18		41	37	11						34	33	3		40	32	25	I	47	45	4	I	38	36	6		41	40	3					
6	32			82	71	15	36		20		37		16	I	35		40		33		22	I	48		30		35	27	30		36		9		40		25	I	46		2	I	39		8	I	46		15	I	44	41	7	
7	29			82	71	15	36		20		39		22		34		36		33		22	I	49		31		27		0		37		12		42		31	I	47		4	I	39		8		41		3		41		0	
8	57	3.6W	8.4E	93	70	33	50	28	79	I	44		38	I	40		60		38	26	46		54		46		43		59		42		27		61		91		61		36	I	50		39		53		33	I	55		34	
9	63	3.9W	8.1E	92		31	47		68		40		25		43	24	79	I	40		54		50	36	39		42	26	62		41	32	28		59		90		60	44	36	I	52		45		51	39	31	I	60	40	50	
670	62	5.2W	6.8E	90	69	30	48		71	I	44	31	42	I	42		75	I	40		54		53		47		40		54		43		34		61		97		63		43		52		45		52		33	I	61		52	
1	57	8.4W	3.6E	90		30	52	26	100	I	45		45	I	43		79		36	25	44	I	52		44		44		70		45		41		52		68	I	68		55		54	35	54		59		51		55		38	
2	53	9.4W	2.6E	89	68	31	50		92	I	47		52	I	43		79		35		40	I	50		39		39		50		41		28		50		61	I	64		45		49		40		57		46		56		40	
3	53	8.9W	3.1E	95		40	50		92	I	45		45	I	43	23	87		36		44		52	34	53		43	25	72		41	31	32		53	30	77	I	61	43	42	I	58		66		54	38	42		58	39	49	
4	42	8.5W	3.5E	83	67	24	38	24	58	I	42		38	I	36		57		34	24	42	I	48		41		34		36		37		19		49		63	I	46		7	I	47		34		46		21		54		38	
675	58	7.4W	4.6E	90	65	38	46		92	I	45		45	I	41		78		38		58	I	48		41		44		76		44		42		55		83	I	68		58		48		37		57		50		55		41	
6	64	7.5W	4.5E	95	64	48	44		83	I	44		42	I	44		91		36		50	I	53	32	66		42		68		39		26		54		80	I	67		56		49		40		57		50		57		46	
		West Span	East Span																																																			

TABLE 6—z.

Avalon, Wis. Deck, Concrete Slab Ballasted Floor. Single Track, Plate Girder.
C.M.&St.P. Span 70'0"

Train:- Engine #263. Class 4-6-0. Kind:- Simple. Cars:- Caboose Only.

Train Headed East
Bridge #20
Records 677-702
Engine 263
Date 7-20-08.

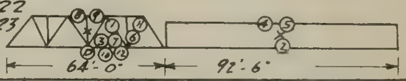


Instrument			Deflection			1	2	3	4				5				6	7				8				9				10	11	12			
Location			Cent. of Span North Girder						South Girder Center Inside Top				South Girder Center Outs. Bottom					North Girder Center Outs. Bottom				North Girder Center Ins. Bottom				South Girder Center Ins. Bottom						North Girder Center Inside Top			
No.	M.P.H.	C.B.	M	S	%E				M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R			M	S	%E	R
677	21	2.0W	36	34	6								24	19	26			20	19	5		27	25	8		26	21	24							
8	17	1.7W	34		0								21		11			19		0		25		0		20									
9	26	1.7W	35		3								19		0			20		5		25		0		22		5							
680	34	1.6W	37		9								20		5			19		0		26		4		24		14							
1	34	1.5W	37		9								25		32			20		5		26		4		28		33							
2	40	1.5W	40		18								26		37			20		5		29		16		29		38							
3	48	1.5W	45		32								28		47			24		26		35		40		30		43							
4	57	1.2W	49		44								29		53			30		58		37		48		35		66							
685	62	0.0	51		50								29		53			30		58		36		44		34		62							
6	67	1.4E	50		47								30		58			30	18	67		32	24	33		32	20	60							
7	72	2.9E	47		38								27		42			26		45		33		38		30		50							
8	67	6.0E	47		38				18	11	64		28		47			29		61		36		50		29		45				28	15	87	
9	68	7.4E	50		47				18		64							29		61		36		50	I										
690	62	8.7W	47		38				18		64		29		53			30		67		39		63		31		55				28		87	
1	57	7.7W	48		41				17		55		27		42			29		61		37		54		32		60				26		73	
2	57	7.0W	46		35				16		45		26		37			29		61		36		50		32		60				27		80	
3	49	2.1W	43	33	30				16		45		22		10			24		33		32		33		26		30				25		67	
4	25	5.4W	36		9				12		9		20		5			20		11		27		13		22		10				18		26	
695	35	5.4E	48	36	33				15		36		27		42			25		39		36		50		30		50				26		73	
6	43	5.8E	39		8				13		18		30		58			20		11		28	25	12		29	21	38				20		33	
7	48	7.2E	44		22				14		27		28		47			22		22		30		20		31		48				22		47	
8	68	7.4E	49	35	40				17		55	I	28		47			28		55		40		60		34		62				26		73	
9	72	8.2W	47		34				18		64	I	27		42			29		61		40		60		33		57				28		87	
700	62	6.3W	51		46								30		58			32		78		40		60		36		72				29		93	
1	63	5.2W	53		51				18		64	I	31		63			32		78		41		64		38		81				28		87	
2	14	3.2W	55		0				11		0		19		0			18		0		25		0		21		0				17		13	

TABLE 6—aa.

Milbern, Ill. Pony Riveted Warren Truss. Double Track. 3 Trusses (1 Heavy-2 Light) Ballasted Floor. Span 64'-0"
Santa Fe. Through Ballasted Floor Double Track. 3 Girders (1 Heavy-2 Light) Plate Girders. Span 92'6"
Train:- Engine 573. Class 2-6-0. Kind:- Compound. Car:- 2 Loaded & Caboose.

Train Headed West.
Bridges 21-22
Records 703-723
Engine 573
Date 7-21-08



Instrument				Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location				Center of Spans			2nd Diag Ins. Edge				North Girder Outs. Bottom				Bot. Chord Outs. Top				North Girder Outs. Top				North Girder Ins. Top				Main Diag. Outs. Edge				Bot. Chord Outs. Bottom				Top Chord Ins. Edge				Top Chord Outs. Edge				Bot. Chord Ins. Bottom				Main Diag. Ins. Edge				Bot. Chord Ins. Top			
No.	M.P.H.	C.B.		M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
703	15	3.5W	3.4W	45	44	2	23	22	5		23	23	0		33	31	6	I	33	30	10		44	40	10		31	29	7		60	58	3		40	38	5		30	27	11		34	34	0	I					8			
4	21	3.4W	3.2W	46		5	24		9	I	29		26		37		19	I	37		23		46		15		31		7		60		3	I	41		8		30		11		37		9	I	29	28	4		7			
705	30	1.6W	1.5W	47		7	24		9	I	24		4		37		19	I	34		13		47		18		34		17	I	59		2	I	42		11		34		26		36		6	I	33		18		12			
6	34	2.5W	2.3W	50		14	30		36	I	29		26		42		35	I+	37		23		50		25		34		17		65		12	I	44		16		35		30		40		18	I	30		7		14			
7	42	1.3W	1.2W	54	43	26	31		41	I	30		30		44		42	I	37		23		52		30		35		21		73	56	30	I	48	36	33		40	26	54		44	32	37	I+	33	26	27		13			
8	48	2.7W	2.6W	53		23	34	21	62		27		17		41	30	37	I	40	29	38		52	39	33		38	28	36	I	70		25	I+	47		30	I	39		50		43		34	I	34		31		11			
9	32	1.5W	1.4W	48		12	24		14	I	26		13		43		43	I	31		7		52		33		37		32	I	69		23	I	40		11		29		12		39		22	I	32		23		9			
710	47	7.9W	7.8W	55	44	25	32		52	I	31		35		46		53	I+	38		31		52		33		40		43	I	65	54	20	I	48	34	41		37	25	48		37	30	23	I	40	24	67		13			I
1	50	3.4E	3.5E	58		32	35		67	I	24		4		41		37	I+	40		38		52		33		40		43	I	70		30	I+	56		65		40		60		35		17	I+	41		71		19			I
2	49	4.1W	4.0W	83	62	34	28		33	I	34		47		42		40	I+	35		21		47		21		40		43	I	66		22	I	43		26		26		4		44		47	I+	40		67		15			I
3	44	1.6E	1.7E	76		23	31	22	41	I	30		30		40	31	29	I	40	30	33		48	40	20		37	29	28		65	58	12	I	48	38	26		37	27	37		43	34	26	I	38	28	36		16			I
4	44	5.6W	5.5W	85	61	39	32		45	I	35		52		41		32	I+	42		40		52		30		38		31	I	68		17	I	47		24	I	30		11		45		32	I	38		36		17			I
715	44	7.3E	7.4E	73		20	32		45	I	32		39		42		35	I	41		37		52		30		38		31	I	64		10	I	47		24	I	30		11		43		26	I	41		46		10			
6	42	6.6W	6.5W	76	60	27	34		55	I	32		39		42		35	I	40		33		53		32		36		24	I	64	56	14	I	44		16		30	26	15		42		23	I	40		43		10			
7	40	3.9E	4.0E	74		23	29		32	I	28		22		41		32	I	43		43		51	39	31		36		24		67		19	I	47	36	31	I	33		27		40	32	25	I	34	26	31		12			
8	38	0.5W	0.3W	74		23	29	21	38	I	29		26		39	30	30	I	36	29	24		51		31		36	28	29		67		19	I	44		22	I	30		15		42		31	I	36		38		10			
9	36	6.8W	6.7W	79		32	31		48	I	34		47		44		47	I	38		31		48		23		35		25	I	62		11	I+	44		22		26		0		40		25	I+	37		42		10			
720	29	4.5E	4.7E	66	59	12	28		33		27		17		41		35	I	35		21		43	38	13		33		18		55	54	2	I	38	34	12		25	25	0		36	30	20	I	33	24	37		10			
1	34	2.8E	2.9E	67		14	27		29	I	25		9		37		23	I	40		38		45		18		36		29		62		15	I	42		24		29		16		37		23	I	27		12		10			
2	26	4.8W	4.7W	64	58	10	25		19	I					33		10	I	35		21		42		11		31		11		54		0	I	35		3		25		0		30		0	I	26		8		5			
3	15	0.4W	0.3W	60		3	21		0		25		9		30		0	I	32		11		40		5		27	27	0		54		0	I	34		0		23				30		0		22	22	0		4			

Truss

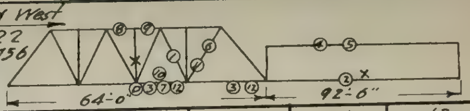
Girder

Secondary Stresses

Truss
Girder

Milbern, Ill. Pony Riveted Warren Truss. Ballasted Floor, Double Track.
3 Trusses (1 Heavy, 2 Light) Span 64'0"
Santa Fe. Through Ballasted Floor, Plate Girder. Double Track. 3 Girders.
(1 Heavy, 2 Light) Span 92'-6"
Train:- Engine 1403. Class 4-4-2. Kind:- Balanced Compound. Cars:- 2 Loaded & Caboose

Train Headed West
Bridges 21-22
Records 724-756
Engine 1403
Date 7-22-08

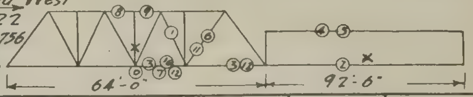


Instrument				Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location				Center of Spans			2nd Diag. Ins. Edge				North Girder Outs. Bottom				Bot. Chord 3rd Pl. Outs. Top				North Girder Outs. Top				North Girder Ins. Top				Main Diag. Outs. Edge				Bot. Chord Outs. Bottom				Top Chord Ins. Edge				Top Chord Outs. Edge				Bot. Chord Ins. Bottom				Main Diag. Ins. Edge				Bot. Chord 2nd Pl. Ins. Top			
No.	MPH	C.B.		M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
724	64	8.4W	9.4W	98	82	20	31	26	19	I	38	33	15	I	53	35	51	I		38		I	63	53	19	I	47	38	24						60	45	33		48	40	20	I	45	35	29	I+								
5	22	3.8E	2.8E	85	81	5	26		0		35		6		37		6	I	43		13	I					40		5						49		9		39				41		17	I					17			
6	34	3.2E	2.2E	87		7	33		27		39		18		44		26	I	43		13	I					40		5	I					56		25		43		8		44		26	I					18			
7	28	2.0E	1.0E	86	80	6	32		23	I	36		9		44		26	I	43		13	I	57		8		45		18	I					54		20		44		10		46		31	I					16			
8	32	0.8E	0.2W	80		0	36		38		34		3	I	46		31	I	43		13	I	57		8		43		13	I					57		27		47		18		43		23	I					13			
9	39	0.6E	0.4W	98	79	24	33		27	I	36	32	13	I	41		17	I	43		13	I	60		13		42	37	14	I					52	44	18		44		10		44		26	I					19			
730	41	0	1.0W	90		14	31		19		37		16		46		31	I+	48		26	I	58	52	12	I	42		14						50		14		43		8		44		26	I					22			
1	52	1.6E	0.6W	95		20	34		31	I	39		22		50		43	I	45	37	22	I	60		15	I	40		8	I					59		34		43		8		48	34	41	I					22			
2	52	1.2E	0.2E	103	78	32	32		23	I	39		22		52		49	I	43		16	I	59		13	I	41		11	I					58		32		46	39	18	I	49		44	I					18			
3	55	7.0W	8.0W	82		5	34		31	I	35		9		49		40	I+					57		10		44	36	22	I	87	58	50	I+	59		34		53		36		50		47	I					17			
						Girder									Bot. Chord 1st Pl. Outside Bar																																				Bot. Chord 1st Pl. Inside Bar			
734	66	9.0E	8.0E	90		15	34		31	I									42		14	I					45		25	I	80		38	I+	61	43	42	I	54		38		50		47	I+								
5	63	8.2E	7.2E	90	77	17	30		15	I+	35	31	13		52	31	68	I	43		16	I	58	51	14	I	45		25	I	90		55	I+	59		37		47		21		50		47	I						31		
6	63	2.6E	1.6E	96		25	31		19	I	35		13		47		52	I	43		76	I	60		18	I	46	35	31	I	89		53	I+	59		37		45		15	I	52		53	I					40		29	
7	74	5.4W	6.4W	83	76	9	32		23	I	37		19		43		39	I	43		16	I+	57		12	I	44		26	I	83		43	I+	52		21		47		21	I	48		41	I+					45		45	
8	15	3.6W	4.6W	76		0	26		0		33		6		33		6		38		3		52		2		35		0		65		12	I	48		12		40		3		36		6	I	46	40	15		32		3	
9		5.0E	4.0E	95	83	14	32		23	I	34	33	3		31	32			40	38	5	I	58	53	9		38	38	0		62	60	3	I	50	45	11		40	40	0		38	35	9	I	52	41	27		37	32	15	
740	50	0.2W	1.2W	104		25	31		19	I	38		15		45		41	I	49		29	I+	62		17	I	46		21	I	82		37	I+	57		27		48		20		48		37	I	63		54		43		34	
1	45	0.2E	0.8W	97		17	29		12	I	37		12		39		22	I	43		13	I	63		19		43		13	I	65		8	I+	56		24		46		15	I	47		34	I	56		37		40		25	
2	49	3.6E	2.6E	64	50	28	30		15	I	38		15		42		31	I	43		13	I	61		15		46		21		75		25	I	58		29		44		10		45		29	I	54		32		40		25	
3	64	1.4E	0.4E	64		28	31		19	I	38		15		43		34	I	42		11	I	62		17	I	50	37	35		75		25		56		24	I	47		18	I	49		40	I	60		46		44		38	
4	63	1.0W	2.0W	58		16	30		15	I	37	32	16		44		38	I	42		11	I	61		15	I	43		16	I	78		28	I+	55		22	I	45		13	I	51		46	I+	62		51		42		31	
745	58	1.8W	2.8W	66		32	30		15	I	36		13	I	52	31	68	I	41		8	I	62	52	19	I	48		30	I	76	59	29	I+	53	44	20		42		5	I	51		46	I	60		46		44		38	
6	57	3.0W	4.0W	67	49	37	35		35	I	33		3	I	42		36	I	44		16	I+	60		15	I	43		16	I	76		29	I+	57		30		49		23		41		17	I	53		29		40		25	
7	49	4.4W	5.4W	63		29	36		38	I	34		6	I	44		42	I	44		16	I	57		10	I	46		24	I	81		37	I+	56		27	I	45		13		52		49	I+	56		37		42		31	
8	56	7.0W	8.0W	63		29	31		19	I	35	31	13		53		71	I	42	37	14	I+	57		10		46	36	28	I	88		49	I+	58		32	I	45	39	15	I	51	34	50	I	57	40	42		43		34	
9	55	4.4E	3.4E	60		22	32		23	I	38		23		43		39	I	43		16	I+	55		6	I	45		25	I	70		19	I+	51		16	I	45		15	I	48		41	I+	55		38		43	31	39	
750	50	3.0E	2.0E	56		14	28		8	I	37		19		38		23	I	46		24	I+	56		8	I	42		17	I	70	58	21	I	53	43	23	I	45		15		46		35	I	48		20		40		29	
1	49	2.6E	1.6E	58	48	21 Truss	29		12		36		16		45	30	50	I	42		14	I	55	51	8	I	44		22	I	76		31	I	51		19	I	43		10		47		38	I	53		32		47		52	
2	44	1.0E	0	58		21	30		15	I	35	30	17		38		27	I	44		19	I	55		8		40	35	14		74		28	I	51		19		42		8	I	43		27	I	52		30		40		29	
3	34	1.0W	2.0W	52		8	34		31	I	32		7		32		7	I	45		22	I	57		12	I	36		3	I	66		14	I	49		14		43		10		41		21	I	48		20		32		3	
4	37	3.4W	4.4W	55		15	35		35		35		17		39		30		44		19	I	54		6	I	40		14	I	78		35	I	48		12		44		13		41		21	I+	43		8		33		6	
5	44	3.2W	4.2W	57		19	30		15	I	34		13		36		20	I	45		22	I	55		8		42		20	I	73		26	I	52		21		44		13		42		24	I	45		12		35		13	
6	40	4.6W	5.6W	55		15	32		23	I	35		17		35		17	I	42		14	I	52		2		39		11	I	66		14	I+	48		12		43		10		43		27	I+	44		10		35		13	
		Truss	Girder																																																			

TABLE 6—ac.

Milbern, Ill.
Santa Fe.
Pony Riveted Warren Truss. Ballasted Floor. Double Track.
3 Trusses (1 Heavy, 2 Light) Span 64' 0".
Through, Ballasted Floor, Plate Girder. Double Track. 3 Girders.
(1 Heavy, 2 Light) Span 92'-6".
Train:- Engine #1403. Class 4-4-2. Kind:- Balanced Compound. Cars:- 2 Loaded + Caboose.

Train Headed West
Bridges 21-22
Records 724-756
Engine 1403
Date 7-22-08

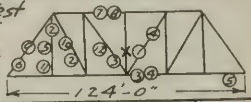


Instrument				Deflection			1	2				3				4				5				6				7				8				9				10				11				12			
Location				Centers of Spans			2nd Diag. Ins. Edge	North Girder Ins Bottom				Bot. Chord 3rd Pl. Outs. Top				North Girder Outs. Top				North Girder Ins. Top				Main Diag. Outs. Edge				Bot. Chord Outs. Bottom				Top Chord Ins. Edge				Top Chord Outs. Edge				Bot. Chord Ins. Bottom				Main Diag. Ins. Edge				Bot. Chord 2nd Pl. Ins. Top			
No.	M.P.H.	C. B.		M	S	%E		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
724	64	8.4W	9.4W	65	40	63														50	35	43										42	27	56						33	17	94	I								
5	22	3.8E	2.8E																													27		0						17		0									
6	34	3.2E	2.2E																																																
7	28	2.0E	1.0E																																	26	25	4													
8	32	0.8E	0.2W																																	32		28													
9	39	0.6E	0.4W																																	31		24													
730	41	0	1.0W					28	22	27																										29		16													
1	52	1.6E	0.6W																																																
2	52	1.2E	0.2E																	39		11	I	22	21	5	I																								
3	55	7.0W	8.0W																	43		23	I					46	22	109	I					31		24													
						Girder						Bot. Chord 1st Pl. Outside Bar																																				Bot. Chord 1st Pl. Inside Bar			
4	66	9.0E	8.0E																					42		100	I	58		163	I	47		74		35		40	I	32		88						38	18	111	I
735	63	8.2E	7.2E	70	46	52		24	22	9	I	35	19	84	I	28	28	0	I	47		34						37		68	I	38		41		32		28	I	34		100									
6	63	2.6E	1.6E	81	46	45		32		46		45		137	I	39		39	I	50		43		43		105		48		118	I	38		41		34		36										38		111	
7	74	5.4W	6.4W	83	43	57		42		91		31		68	I	50		78	I					30		43	I	50		127	I	38		41	I													32		78	
8	15	3.6W	4.6W					23		5						28		0		35		0		21		0										25		0						28	28	0		18		0	
9	19	5.0E	4.0E													38		36		40		14																						30		7		18		0	
740	50	0.2W	1.2W																																																
1	45	0.2E	0.8W					25	22	14	I									40		14																													
2	49	3.6E	2.6E	52	32	62		27		23	I									39		11																													
3	64	1.4E	0.4E	48	30	60		47		114		39		105		42		50	I	51		46		43		105	I	59		168	I					36		44						50		79		42		134	
4	63	1.0W	2.0W	42	30	40		36		64		42		121	I	44		57		47		34		43		105		63		186	I					37		48						57		104		44		144	
745	58	1.8W	2.8W					27		23	I	39		105	I					50		43	I					67		204	I													39		39		36		100	
6	57	3.0W	4.0W					22		0	I					36		29																																	
7	49	4.4W	5.4W																																																
8	56	7.0W	8.0W			Truss						32		68	I	40		43	I																																
9	55	4.4E	3.4E									26		37	I																																				
750	50	3.0E	2.0E																																																
1	49	2.6E	1.6E									27		42	I																																				
2	44	1.0E	0					28	22	27																																									
3	34	1.0W	2.0W																													43		59																	
4	37	3.4W	4.4W																													48		78																	
755	44	3.2W	4.2W																																																
6	40	4.6W	5.6W																																																

TABLE 6—ad.

Carrolton, Mo Riveted, Through, Shallow Suspended, Ballasted Floor, Double Track.
Santa Fe
2 Trusses Span 124'-0"

Train Headed West
Bridge 23
Records 757-782
Engine 1822
Date 7-23-08



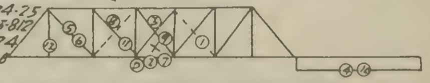
Train:- Engine #1822. Class 2-6-2. Kind:- Balanced Compound. Cars:- 4 Loaded & Caboose.

Instrument			Deflection			1						2				3				4						5				6				7				8				9				10				11				12			
Location			Center of Span			3rd Diag. Outs. Top						Main Diag. Ins Top				2nd Diag. Ins. Top				3rd Diag. Ins. Bottom						Hip Vert Outs. West				End Post Outs. Top				Top Chord Outs. Top				Top Chord Ins. Bottom				End Post Ins Bottom				Main Diag. Outs. Bottom				Hip Vert. Ins East				2nd Diag. Outs. Bottom			
						Comp.			Tens.											Comp.			Tens.																																		
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
757	6	7.2W	73	73	0	21	21	0	26			36	35	3		28	26	8		17	15	13	24			16	16	0		32	32	0			28				32			34	32	6													
8	15	6.1W	75		3	21		0	32			39		11		27		4		16		7	25			18		13		35		9		28		0		34		6		34		6		28	27	4									
9	28	4.0W	76		4	24		14	32			39		11		30		15		16		7	27			17		6		33		3		30		7		32		0		36		12		28		4									
760	36	2.0W	80		10	24		14	29			42		20		27		4		17		13	28			21		25		38		19		35		25		39		22		37		16		30		11						24	22	9	
1	50	1.2E	81		11	24		14	33			43		23	I	33		27		17		13	30			21		25		35		9		37		32		38		19		35		9		33		22						30		36	
2	49	3.2E	83	72	15	25		19	36			47		34	I	35		35		14			31			17		6		40	31	28		37	27	37		40	31	29		39	31	26		33		22						29		32	
3	42	5.6E	80		11	29		39	31			42	34	24		31		19	I	16		7	28			21		25		37		19		35		30		38		23		38		23		29	26	11						28		27	
4	56	8.9W	84	71	18	27		29	33			43		27	I	33		27	I	16		7	29			19		19		32		3		32		18		38		23		36		16		31		19						29		32	
765	61	6.2W	75		6	36		71	38			36		6		29		12		18		20	27							34		9		33		22		36		16		37		19		28		8						25		14	
6	57	3.0E	76	70	9	25		19	32							33		27		17		13	29							37		19		34		26		36		16		38		23		32		22						25		14	
												Hip Vert. Ins. West				Bot. Chord 4th Pl. Bot. Inside				Bot. Chord 4th Pl. Top Outs.						Floor Beam																															
767	48	6.8E	88	74	19	22		5	42			29	28	4	I	16	11	45		18	10	80				37	29	28		40	32	25		37	28	32		38	32	19		41	32	28		34	27	26						25		14	
8	49	8.2W	86		16	24		14	35			29		4	I	13		18								38		31		38		19		38		36		39		22		42		31		33		22						26		18	
9	47	4.0W	80		8	26		24	33			32		14	I	14		27		17		70				49		69		37		16		33		18		36		12		37		16		28		4		27	26	4		24		9	
770	42	4.2E	77	13	5	25		19	33			28		0	I					16		60				41		41		36		13		34		21		35		9		38		19		31		15		26		0		25		14	
1	54	6.0E	81		11	25		19	29			30		7	I	18		63		17		70				33		14		40		25		33		18		36		12		37		16		31		15		30		15		25		14	
2	50	5.4E	83	72	15	25		19	34			30		7	I	23		109		19		90				41		41		40		25		34		21		37		16		40		25		31		15		27		4		24		9	
3	53	7.0E	85	71	20	26		24	32			28		0	I	20		82		15		50				45		55		35	30	17		36	26	38		36	30	20		35	30	17		30	26	15		28		8		26		18	
4	67	8.6W	77	70	10	27		29	27			33		18	I	14		27		14		40				44		52		33		10		30		15		32		7		33		10		26		0		33		27		24		9	
775	52	8.0W	81		16	27		29	26			31		11	I	19		73		17		70				46		59		36		20		33		27		35		17		36		20		27		4		28		8		25		14	
6	40	7.2W	77		10	26		24	29			35		25	I	16		45		16		60				45		55		30		0		31		19		33		10		33		10		27		4		30		15		26		18	
7	50	3.8W	77	69	12	27		29	31			35		25	I	18		64		18		80								33		10		32		23		32		7		35		17		26		0		34		31		29		32	
8	46	1.4W	73		6	25		19	30			34		21	I	16		45		10		0				48		65		37	28	32		32	24	33		31	28	11		33	28	18		29	25	16		32		23		30		36	
9	44	3.4E	73		6	28		33	30							18		64		12		20				43		48		39		39		30		25		32		14		34		21		28		12		29		11		28		27	
780	40	3.6E	72	68	6	28		33	30			30		7		15		36		12		20				43		48		34		21		20		25		30		7		32		14		27		8		27		4		26		18	
1	40	5.0E	70		3	25		19	30			30		7	I	12		9		14		40				38		31		32		14		28		17		30		7		33		18		27		8		28		8		28		27	
2	37	8.0E	70		3	26		24	28			29		4	I	13		18		11		10				39		35		32		14		29		21		29		4		32		14		25	24	4		28		8		25		14	

TABLE 6—ae.

Hardin, Mo Pin-Connected, Shallow Suspended Ballasted Floor. Double Track.
(2 Trusses) Span 149'0"
Santa Fe Deck Plate Girder. Ballasted Floor Double Track (4 Girders-)
(2 to each track) Span 70'0"
Train:- Engine #1824 Class 2-6-2. Kind:- Balanced Compound. Cars:- 4 Loaded & Caboose.

Train Headed W. ←
Bridges 24-25
Records 783-812
Engine 1824
Date 7-24-08



Instrument			Deflection				1						2				3						4						5				6				7				8				9						10				11				12			
Location			3rd Pl Point				Counter 5th Panel						Bot. Chord Cent. Pl. Ins N Bar				3rd Diag. Outs Bar						N. Girder N. Track Ins Bottom						Main Diag. Outs. Bar				Main Diag Ins Bar				Bot. Chord Cent. Pl Ins S. Bar				2nd Diag. Outs Bar				3rd Diag Ins. Bar						N. Girder N. Track Outs Bottom				2nd Diag. Ins Bar				Hip Vert Ins East			
							Tens			Comp							Tens			Comp			Eng			Car																			Tens			Comp														
No.	MPH	C B	M	S	%E		M	S	E	M	S	E	M	S	%E	R	M	S	E	M	S	E	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R
783	26	1.2W	94	93	1	↑	15	13	15	31			23	21	10		17	16	6	8			48	43	12	8			37	35	6		29	26	12						36	32	12		36	31	16	14							40	34	18					
4	36	06E	100		8		15		15	30			23		10	I	17		6	12			48		12				38		9		29		12		20	18			36		12		34		10	15			35	31	13		40		18					
785	48	4.8E	95	92	3		13		0	35			22		5	I	17		6	10			48		12	23			37		6		28		8		20				38		19		35		13	15			34		10		40		18					
6	50	8.0W	95		3		15		15	32			22		5	I	17		6	13			49		14	25			34	34	0		27	25	8		18				37		16		34		10	15			38		23		39		15					
7	52	1.6W	94	91	3		16		13	30			22	20	10	I	18		12	14			52		21	25							28		12		19				35	31	13		37		14	14			39		26		38	33	15					
8	48	2.8E	96		5		14		8	33			22		10	I	18		12	10			46		10	25			37		9		26		4		18				35		13		34	30	13	15			34		10		40		21		40	26	54	
9	54	8.8W	90	90	0		16		23	30			24		20	I	18		12	14			49		17	26			37		9		26		4		19	17			34		10		31		3	16			35	30	17		36		9		42		61	
790	59	12W	88	88	0	Truss	14		8	29			23		15	M	16		0	13			48		14				44	33	33		27	24	12		20				30	30	0		33		10	14			35		17		37	32	16		36		38	
1	60	2 9E	84	87			15		15	29			21	19	10	I	16		0	12			46		10				38		15		26		8		19				33		10		33		10	12			33		10						39		50	
2	59	2.1E	85	85	0		15		15	29			20		5	I	18		12	8			49		17				38		15		26		8		19				31		3		34		13	12			35		17		35		9		39		50	
3	57	4.8W	85	84	1		15		15	29			19		0	M	18		12	10			47		12	24			37		12		26		8		18				31		3		31	31	0	14			33		10		33		3		39		50	
4	12±	3.4W	97	96	1																		46	43	7					35			28	26	8		19	18			31		3								33	31	6						32		23	
795	37	5.2E	98	96	2		14		8	35			23	22	5	I	18		12	8			49		14				38		9		27		4		19				35	32	9		32		3	17			32		3		38	34	12		35		35	
6	48	0.2E				↓	17		31	33			24		9	I	17		6	12			48		12				39		11		28		8		19				35		9		34		10	15			33		6		40		18		33		27	
7	42	3 1E				↑	15		15	31			23		5	M	18		12	12			48		12				40		14		27		4		19				36		12		34		10	13			34		10		38		12		33		27	
																																													Diagonal 4th Pl Outs Bottom																	
8	61	3.1W	110	99	11		15		15	32			23		5	M	16		0	12			48		12	25			37	34	9		27	25	8		19				34	31	10		24	23	4	14			34		10		37	33	12					
9	52	6.4W	100	98	2		16		23	30			21	21	0	I	17		18	8			45		5				38		12		29		16		20				35		13		25		9	14			39		26		38		15		30		15	
800	58	6.9E	107		9		13		0	31			24		14	I							48		12	25			36		6		26		4		20				33		6		24		4	14			32		3		35		6		32		23	
																	Diagonal Cent Pl Ins Bar																				Stringer Cent Pl. Ins Top																									
1	49	61W	112		14								21		0	I	22	20	10	11			47	42	12	24			39		15		27		8		13	12	8		30	30	0		24		4	14							36	32	12		31		19	
2	52	02W	102		4		15		15	26			20			I	23		15	12			47		12	24			38		12		27		8		13		8		30		0		25		9	12			35	30	20		36		12		27		4	
3	40	1.3W	101		3		15		15	30			20	20	0	I	22		10	9			45		7				39	33	18		26	24	8		13		8		30		0		25	22	14	13			32		7		35		9		26		0	
4	50	2 4E	100		2		16		23	28			20		0	I	24		20	7			47		12	26			34		3		28		17		13		8		32		7		26		18	14			32		7		38		19		36		38	
805	46	3.2E	102		4	Girder	15		15	26			22		10	M	23		15	6			46		10				36		9		27		12		10				33		10		25		14	13			31		3		36		12		34		31	
6	45	4.8E	100		2		13		0	29			20		0	M	23		15	7			45		7				36		9		26		8		16		33		36		20		26		18	12			31		3		38		19		31		19	
7	43	6.6E	99		1		18		38	26			22	19	15	I	22		10	9			45		7				39		18		29		21		15		25		36		20		26		18	12			34		13		35		9		32		23	
8	48	2.4E	108	103	5		14		8	30			23	22	5	I	21		5	16			48	43	12				40	35	14		32	26	23		15	13	15		38	32	19		25	23	9	15			33	31	6		43	34	27		36		38	
9	27	1.1E	104		1								23		5	I	23		15	9			48		12	16			41		17		31		19		14		8		35		9		25		9	14			34		10		37		9		30		15	
810	36	28E	103	102	1		15		15	32			23		5	I	23		15	16			48		12	16			39		11		30		15		15		15		35		9		25		9	14			34		10		38		12		34		31	
1	42	4.2E	103		1		13		0	32			22		0	M	22		10	14			46		7				40		14		29		11		14		8		38		19		25		9	13			33		6		39		15		35		35	
2	15	2 8E	102		0		15		15	27			21	21	0		22		10	7			45		5				35		0		27		4		15		15		36		12		25		9	14			30				39		15		26		0	
						↓																																																								

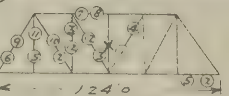
TABLE 6—af.

Carrolton, Mo.
Santa Fe.

Through, Riveted, Shallow Suspended Ballasted Floor Double Track.
(2 Trusses) Span 124'0"

Train:- Engine #1115 Class 2-6-2. Kind:- Compound. Cars:- 4 Loaded & Caboose.

Train Headed W.
Bridge #23
Records 813-837
Engine #1115
Date 7-25-08.



Instrument			Deflection			1						2				3				4					
Location			Center of Span			3rd Diag Outs Top						Main Diag Ins Top				2nd Diag. Ins. Top				3rd Diag. Ins Bottom					
						Comp			Tens											Comp			Tens		
No.	MPH	C.B	M	S	%E	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E
813	25	2.9E	60	57	5	17	16	6	22			34	30	13		29	28	4							
4	30	5.6E	64		12	17		6	25			34		13		29		4		10	10	0	24		
815	33	7.5E	65		14	25		56	22			35		17		35		25		16		60	22		
6	42	6.1E	77		35	24		50	27			39	29	34		34		21		16		60	24		
7	45	7.4W	74		30	23		44	26			37		27		37		32		11		70	30		
8	49	4.3W	69	56	23	25		56	25			36	25	29		35		25		17		70	26		
9	50	1.3W	77		38	19		19	22			38		36		36		29		15		50	23		
820	54	1.3W	76		36	18		12	23			37	27	37		33		18		12		20	15		
1	54	0.2W	73	55	33	20		25	22			36		33		37		32		15		50	22		
2	50	2.4E	76		38	21		31	21			34		36		34		21		16		60	24		
												7th Flr Bm 14 Pt W Bottom													
3	50	7.9W	73	59	24	22		37	24			33	25	32		37		32		13		30	29		
4	49	7.4W	74		25	20		25	27			30		20		39		40		10		0	29		
825	28	1.3E	60	58	3	20		25	17			32		28		29		4		12		20	21		
6	48	5.6E	73		26	22		37	27			30		20		40		43		15		50	26		
7	44	5.9E	73	57	28	21		31	27							39		40		11		10	34		
																2nd Pl Post Inside East									
8	48	8.8W	71	56	27	23		44	29			30		20						14		40	28		
9	42	8.1W	69	55	25	22		37	26			28		12		26	17	53		15		50	24		
830	44	7.5W	68	54	26	23		44	25			29		16		24		41		14		40	25		
1	46	6.0W	68		26	24		50	25			32		28		24		41		14		40	27		
2	40	5.5W	65	53	23	22		37	24			35		40		26		53		14		40	24		
3	45	4.2E	70		33	20		25	29			33		32		22	16	37		16		60	28		
4	35	4.1E	57		8	19		19	25			29		56		18		12		13		30	20		
835	36	7.5E	63	56	12	20		25	24			29		56		22		37		16		60	21		
6	37	7.8W	62		11	22		37	24			30		20		22		37		14		40	21		
7	42	4.9W	70		25	18		12	29			31		24		25		53		15		50	24		

Instrument		5				6				7				8			
Location		Hip Vert. Outs West				End Post Outs. Top				Top Chord Outs Top				Top Chord Ins. Bottom			
No.	MPH	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
813	25					29	28	4		24	22	9		25	23	9	
4	30					29		4		25		14		25		9	
815	33					32		14		27		23		29		26	
6	42					36		28		33		50		35		52	
7	45					35		25		30		36		32		39	
8	49					35	27	30		29		32		30		30	
9	50					26				31		41		30		30	
		Hip Vert Inside East															
820	54	32	23	39		31		11		37		68		30		30	
1	54	32		39		31		11		30		36		30		30	
2	50	30		30		30		7		33		50		31		35	
		7th Floor Beam 14 Pt E Bottom															
3	50	30	25	20		36	28	29		30		36		30		30	
4	49	33		32		36		29		27		23		30		30	
825	28	30		20		31		11		22		0		25		9	
6	48	38		52		36		29		30		36		31		39	
7	44	32		28		37		32		31		41		32		39	
8	48	30		20		35	27	30		27		23		29		26	
9	42	32		28		39		44		30		36		28		22	
830	44	37		48		39		44		30		36		27		17	
1	46	31		24		35		30		27		23		28		22	
2	40	33		32		33		22		25		14		30		30	
3	45	36		44		33		22		34		55		33		43	
4	35	30		20		33		22		22		0		27		17	
835	36	30		20		33	28	18		26		19		28		22	
6	37	31		24		34		21		25		14		26		13	
7	42	33		32		36		29		28		27		32		39	

Instrument		9				10				11				12			
Location		End Post Ins Bottom				Main Diag Outs Bottom				Hip Vert Ins East				2nd Diag. Outs Bottom			
No.	MPH	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
813	25	29	28	4		24	21	14		24	23	4					
4	30	28		0		24		14		28		22					
815	33	32		14		25		19		30		30					
6	42	35		25		27		28		37		61					
7	45	36		28		27		28		35		52					
8	49	35	27	32		25	20	25		35		52					
9	50	34		26		25		25		36		56		25	15	67	
										Hip Vert Outs West							
820	54	32		19		26		30						21		40	
1	54	31		15		24		20						27		80	
2	50	29		7		25		25						22		46	
										Hip Vert Ins East							
3	50	33	28	18		27	21	28		30	24	25		20		33	
4	49	33		18		28		33		30		25		21		40	
825	28	27								22				15		0	
6	48	33		18		31		48		25		4		20		33	
7	44	34		21		30		43		28		17		22		46	
														2nd Pl Post Outs West			
8	48	31	27	15		34		62		21							
9	42	35		30		28	20	40		30		25					
830	44	32		18		28		40		30		25					
1	46	31		15		31		55		33		38		25	13	92	
2	40	29		7		28		40		40		67					
3	45	33		22		30		50		32		33		24		84	
4	35	27		0		24		20		25		4		17		31	
835	36	30	28	7		27	21	28		30		25		16		23	
6	37	29		4		26		24		30		25		16		23	
7	42	31		11						39		63		20		54	

TABLE 6—ag.

Hardin, Mo
Santa Fe

Pin-Connected, Shallow Suspended Ballasted Floor. Double Track (2 Trusses) Span 149' 0"
Deck Plate Girder. Ballasted Floor. Double Track (4 Girders, 2 to each Track) Span 70' 0"

Bridges 24-25
Records 838-845
Engine 542
Date 7-27-08
* See Sketch below

Train:- Engine 542. Class 4-4-2. Kind:- Balanced Compound. Cars:- 4 Loaded & Caboose.

Instrument			Deflection			1						2				3				4				5				6				7				8				9						10				11				12			
Location			Cent. of North Plate Girder or North Truss			Counter 5th Pl.						Hip Vert. Outs. West				3rd Diag. Outs. Bar				N. Gird. N. Tck. Ins. Bot.*				Main Diag. Outs. Bar				Main Diag. Ins. Bar				Top Chd. Ins. Top				2nd Diag. Outs. Bar				3rd Diag. Ins. Bar						N. Gird. N. Tk. Outs. Bottom				2nd Diag. Ins. Bar				Hip Vert. Ins. East			
						Tens.			Comp.																															Tent.			Comp.														
No	MPH	C.B	M	S	%E	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R
838	14	0.6W	96	92	4	9	8	12	21			8	8	0		15	13	15						41	40	2		33	32	3		28	28	0		30	30	0		32	30	7	8			30	30	0		30	30	0		31	25	24	
9	27	3.0E				10		25	22			8		0		14		8		35	35	0		40		0		32		0		29		4		30		0		30		0	11			30		0		29				27		8	
840	39	3.4E				10		25	21			8		0		16		23		35		0		40		0		33		3		28		0		30		0		27			14			31		3		32		7		32		28	
1	39	2.0E	92	91	1	10		25	20			8		0		14		8		36		3		41	39	5		32		0		26	26	0		30	28	7		30		0	12			30		0		33	28	18		32		28	
2	56	3.4E	93	90	3	10		25	21			12		50		19		46		38		9		42		8		32	31	3		26		0		34		21		31		3	13			32		7		35		25		33		32	
3	67	8.1E	95	90	6	12		50	21			11		38		13		0		39		11		41		5		31		0		24	24	0		33		18		31		3	18			33		10		38		36		37		48	
4	56	8.9E				8		0	20			12		50		13		0		40		14		41		5		33		6		25		4		31	26	19		33		10	15			34		13		33	26	27		31		24	
845	55	0.0	79	78	1	10		25	15			10		25		13		0		37		6		38	38	0		31		0		26		8		30		15		33		10	13			34		13		30		15		30		20	
Train:- Engine 1115. Class 2-6-2. Kind:- Compound. Cars:- 3 Loaded & Caboose.																																																									
846	46	3.3E	92	70	31	12	8	50	27			9	9	0		16	13	23		40	35	14		45	34	32		35	28	25		32	22	45		40	25	60		36	28	29	14			39	28	39		38	26	46		35	26	35	
7	55	8.0E	75		7	12		50	20			11		22		13		0		43		23		37		9		33		18		25		14		30		20		31		11	15			36		29		30		15		31		19	
																3rd Diag. Ins. Bar																																									
848	46	7.2W	87	69	26	10		25	27			13		45						42		20		41		21		34		21		32	21	52		33		32												35		35		33		27	
																								Cent. Floor Bm. Cent. Pl. 1/4 Point																																	
849	53	1.1W	74	68	9	11		38	18			12		33		25	15	66		45	34	32		17	11	54		31	27	15		23		10		27		8		22	20	10	10			38		36		28	25	12		35		35	
																																				Stringer 4th Pl. Outs. Bot.																					
850	42	1.6E	86		26	9		12	20			9		0		25		66		43		26		19		73		37		37		30	20	50						26		36	9			33		18		35		40		37		42	
1	37	4.1E	83	66	26	9		12	20							19		27		37		9		14		27		33		22		28		40						25		25	9			33		18		30		20		31		19	
												Stringer 4th Pl. Outs. Top																																													
852	40	6.9E				10		25	20			16	15	7		18		20		42	35	20		14		27		35	28	25		27	22	23		17	17	0		23		15	13			35		25		35	26	35		29		12	
3	44	8.2W	104	82	27	10		25	29			15		0	I	22		47		45		29		13		18		37		32		33		50		18		6		22		10	14			37		32		39		50		33		27	
4	52	8.5E	96	81	19	10		25	18			17		13	I	20		33		44		26		14		27		32		14		24		9		27		59		23		15	11			36		29		32		23		36		38	
855	53	1.9W	100		23	9		12	20			17		13	I	20		33		45	34	32		12		9		29		4		28		27						23		15	10			37		32		26		0		34		31	
6	46	2.1E	98		21	9		12	26			20		33	I	30		100		43		26		18		64		32	27	19		32	21	52		24		41		25		25	13			36		29		36	25	44		36		38	
7	47	7.4E	93		15	10		25	22			18		20	I	22		47		41		20		13		18		30		11		29		38		21		23		24		20	12			34		21		35		40		30		15	
8	42	8.2W	101	80	26	9		12	25			17		13	I	18		20		41	33	24		13		18		35		30		30		43						22		10	15			35		25		38		52		32		23	
9	34	7.7W				10		25	17			16		7		16		7		33		0		12		9		31		15		23		10		22		29		20		0	10			29		4		28		12		31		19	
860	16	8.1W	83		4	7			20			16		7	I	15		0		34		3		11		0		28	26	8		20	20	0		20		18		20		0	9			28		0		27		8		29		12	

Train Headed W.

Bridges 24-25
Records 846-860
Engine 1115
Date 7-27-08

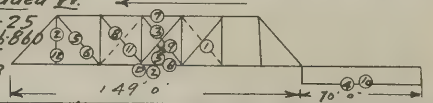
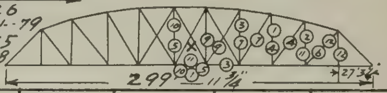


TABLE 6—ah.

Purcell, Okla Through, Pin-Connected, Open Floor, Curved Top Chord
Santa Fe Single Track, South Span. Span 300

Train Headed South
Bridge # 26
Records 861-79
Engine 1435
Date 7-29-08



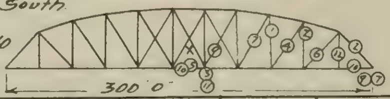
Train:- Engine # 1435 Class 4-4-2 Kind:- Balanced Compound. Cars:- 5 Loaded & Caboose.

Instrument			Deflection			1						2				3						4						5				6				7						8	9				10				11						12			
Location			So. Middle Pl. Point			3rd Pl. Post Outs. So.						2nd Pl. Post Outs. So.				4th Pl. Post Outs. So.						3rd Pl. Post Ins. North						6th Pl. Post Ins. North				Main Diag. Ins. Bar				4th Pl. Post Ins. North							5th Pl. Post Ins. North				6th Pl. Post Outs. So.				2nd Pl. Post Ins. North						Main Diag Outs. Bar			
						Comp			Tens							Tens			Comp			Comp			Tens											Comp			Tens															Comp			Tens						
No.	M.P.H.	C.B.	M	S	%E	M	S	E	M	S	E	M	S	%E	R	M	S	E	M	S	E	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E		M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R
861	48		233	222	5	34	28	21	5			37	32	16	I	16	9	78	7			20	16	25	25			34	29	18	I	49	43	14	M	7			25				33	27	22	I	0				27	25	8	12			48	45	7	M
2	30	8.4S	226		2	36		29	5			34		6	I	10		11	7			19		19	19			34		18		47		9	M	7			22				30		11	I	0				26		4	10			48		7	M
3	16	8.3S	226		2	28		0	6			33		3		9		0	4			16		0	20			32		10		47		9		6			20				27		0	I	0				27		8	8			48		7	
4	29	4.8S	223	221	1	34		21	5			34		6	I	11		22	4			18		12	16			35		21		47		9	M	7			23				31		15	I	0				27		8	11			47		4	M
865	32	2.5S	222		0	35		25	5			32		0	I	10		11	5			18		12	19			34		18		45		5	M	8			21								0				27		8	9			47		4	M
6	40	1.8N	220	220	0	35		25	6			32		0	I	10		11	4			18		12	19			38		31	I	46		7	M	6			23				28		4	I	0				27		8	8			48		7	M
7	39	7.4N	222		1	33		18	7			32		0	I	10		11	4			20		25	21			35		21	I	48		12	I	7			23				31		15	I	0				24			11			48		7	M
																												6th Pl. Post Outs. South																			6th Pl. Post Ins North													
868	28	9.0N	224		2	35		25	4			33		3		11		22	3			20		25	19			0				48		12	I	8			21				31		15	I	33	27	22		25		0	12			48		7	M
9	48	6.4S				35		25	4			34		6	I	17		89	3			19		19	20			0				47		9		9			25								33		22	I	27		8	10			49		9	M
																						2nd Diag Ins. Bar														3rd Diag. Ins Bot.							4th Diag. Ins. Bar																	
870	47	2.0N	226	218	4	31		10	5			31	31	0	I	16		78	3			41	34	21	M			0				46		7	M	33	30	10	M				37	30	23	M	33		22	I	26		4	10						
																Floor Beam 5th Pl. Pt N. Bot.												Bot. Chord Cent Pl. Outs Cent.																			Bot. Chord Cent. Pl. 4th Bar fm outs.				Outs. Stringr. E Pair C. Pl. Ins. Bottom						Hip Vert. N. Inside			
871	51	7.3N	223	215	4	31		10	10			34		10	I	49	35	40	I			37		9	M							49		14	M	31		3	M				32		7	M	29	25	16	I	24	16	50	I			49	44	11	I
						Outs Stringer W. Pair Bottom Ins. Cent. Pl.																																																					
872	60	9.0S	214	206	4							30			I	48		37	I			40		18	I			38	30	27	I	46		7	M I	35		17	M				35		17	M	28		12	I	24		50	I			52		18	I
3	46	5.6S	214		4							30			I	47		34	I			34		0	M			40		33	I	45		5	M I	35		17	M				33		10	M	28		12	I	23		44	I			51		16	
4	40	4.0S	205	205	0	50	36	39	I			29	30		I	45		29	I			34		0	M			34		13	I	45		5	I	33		10					33		10	M	26		4	I	24		50	I			50		14	
875	47	0 0	213		4	35			I			30		0	I	47		34	I			35		3	M			35		17	I	45		5	M I	32		7	M				32		7	M	27		8	I	24		50	I			48		9	I
6	36	2.0N	207		1	36		0	I			32		7	I	43		23	I			34		0	M			34		13	I	45		5	M	32		7	M				32		7	M	26		4	I	24		50	I			51		16	I
7	39	4.8S	211		3	37		3	I			30		0	I	39		11	I			34		0	M			35		17	I	44		2	M	33		10	M				33		10	M	25		0	I	24		50	I			50		14	I
8	14	1.4N	205		0	37		3	I			29				39		11				37		9	M			30		0		45		5													24			I	20		25	I			48		9	
9	36	4.8N	205		0	38		6	I			29			I	43		23	I			40		18	M			31		3	I	43		0	M	32		7	M								26		4	I	24		50	I			50		14	I

TABLE 6—ai.

Purcell, Okla. Through, Pin-Connected, Open Floor, Curved Top Chord,
Santa Fe. Single Track. South Span. Span 300'-0."
Train:- Engine #1066 Class 2-6-2. Kind:- Compound Cars:- 5 Loaded & Coach.

Train Headed South
Bridge #26
Records 880-910
Engine 1066.
Date 7-30-08.

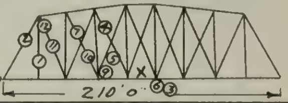


Instrument			Deflection			1				2				3				4				5				6				7				8	9				10				11				12			
Location			South Middle Pl. Point			3rd Pl. Post Outs So.				2nd Pl Post Outs. So.				Floor Beam 5th Pl. Pt. N Bottom				2nd Diag. Ins Bar				Bot. Chd Cent Pl. 3rd Bar fm Outs				Main Diag. Ins Bar				3rd Diag. Ins. Bar					4th Diag Ins Bar				Bot Chd Cent Pl 4th Bar fm Outs				Floor Beam 5th Pl Pt So Bottom				Hip Vert N Ins			
No.	MPH	C B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
880	24	6.2S				30	26	15	I	37	27	37		39	34	15		42	36	17		35	30	17		51	42	21	I	33	28	18	M		34	30	13	M	31	25	24	I	36	32	12		47	43	9	
1	25	3.2S	218	201	8	27		4	I	32		18		45		32		44		22		35		17		50		19		33		18			35		17		26		4	I	39		22		49		14	
2	35	1.6N	207	200	4	29		12	I	34		26	I	44		29		41		14	I	34		13	I	47		12	I	33		18			34		13	M	28		12	I	40		25		48		12	
3	12	0.1N	198	198	0	27		4		27		0		34		0		36		0		31		3						28		0			32		7	M	26		4		35		9		43		0	
4	18	1.9N	206		4	27		4	I	29		7		35		3		36		0	M	30		0		43		2	M	33		18	M		32		7	M	26		4		35		9		47		9	
885	20	3.3N	203		3	28		8	I	30		11		36		6		33			I	32		7		44		5	M	28		0	M		32		7		25		0		39		22		46		7	
6	36	7.9S	210	197	7	28		8	I	33		22	I	36		6	I	38		6	I	35		17	I	46		10		32		14			32		7	M	28		12	I	43		34	I	50		16	
7	25	4.3S	200	196	2	29		12	I	31		15		38		12		36		0		33		10		44		5	M	29		4	M		30		0		26		4	I	39		22		47		9	
8	36	0.9N	201	194	3	27		4	I	31		15	I	50		47	I	40		11	I	33		10	I	45		7	I	32		14			30		0	M	25		0	I	41		28		48		12	
9	27	2.9N	233		20	30		15	I	34		26		43		26	I	42		17		36		20		47		12	M	38		36	M		36		20	M	35		40	I	36		12		48		12	
890	25	6.1N	236		22	30		15	I	35		30		40		18		47		30		37		23		47		12	M	39		39	M		38		27		32		28		37		16		47		9	
1	28	5.9N	222	193	15	28		8	I	30		11	I	41		21		40		11		35		17		45		7	M	38		36	M		39		30		31		24		34		6		51		19	
2	31	8.2N	204	192	6					34		26		38		12	I					31		3	I	44		5		32		14			39		30		27		8	I	37		16		47		9	
3	32	6.2S	208	190	9	28		8	I	33		22	I	40		18	I					32		7	I	43		2	M	29		4	M						27		8	I	37		16		52		21	
4	29	4.1S	213	189	13	28		8	I	29		7		38		12	I	39		8		33		10		43		2	M	34		21			40		33		27		8	I	39		22		50		16	
895	42	3.4N	198	188	5	29		12	I	31		15		41		21	I	39		8	I	30		0	I	41			M	33		18			32		7	M	28		12	I	41		28		60		40	
6	42	8.3S	196	187	5	30		15	I	28		4	I	36		6	I	39		8	I	33		10	I	44		5	M	28		0	M		31		3	M	31		24	I	37		16		57		32	
7	52	7.6S	204	186	10	27		4	I	29		7	I	41		21		37		3	I	34		13	I	44		5	M	29		4	M		28			M	28		12	I	40		25	I	50		16	I
8	21	1.0S	208	206	1	26		0		33		22		39		15		34				31		3		44		5	M	27			M						25		0		34		6		46		7	
9	18	5.5N	207	204	1	27		4	I	31		15		36		6		34			M	33		10		41			M	33		18	M		30		0	M					36		12		46		7	
900	11	5.2N	198	198	0	26		0		29		7		34		0		34			M	33		10		42		0	M	29		4	M		33		10	M	27		8		34		6		45		5	
1	18	7.0N												34		0		35			M	33		10		44		5															33		3		45		5	
2	40	5.2N	213	198	8	28		8	I	35		30	I	43		26	I	37		3		33		10	I	43		2	M	33		18			32		7	M	28		12	I	37		16	I	54		26	
										End Post Ins. Top																				So End F.B. Outs. Bot. Comp. Tens.					So End F.B. Bot Ins. (Tension)				N.W.-S.E Lat. 1st Pl.											
903	44	8.2S	216	198	9	27		4	I	28	30		I	37		9	I	43		19		37		23		45		7	M	7		15			13			I					37		16	I	55		28	
4	47	8.0S	213	196	9	27		4	I	33		10	I	40		18	I	41		14		35		17	I	45		7	M	10		14			10			I					35		9	I	56		30	
905	52	3.6N	212	194	9	28		8	I	37		23		42		24		43		19		33		10	I	45		7	M	9		17			8				12			I	35		9	I	56		30	
6	51	3.8S	210	192	9	30		15	I	35		17		45		32	I	37		3	I	34		13	I	45		7	M	10		16			8			I	12			I	49		53		60		40	
7	33	2.3S	205	190	8	26		0	I	36		20		42		24	I	38		6		33		10	I	42		0	M	10		14			7				12			I	32		0		50		16	
8	28	8.7N								38		27						45		25		39		30		45		7	M																					
9	27	7.3S	214	186	15					32		7						40		11		37		23		49		17	M																					
910	19	8.1S	184	184	0					34		13						36		0	M	32		7		43		2	M																					

TABLE 6—aj.

Purcell, Okla Through, Pin-Connected, Open Floor, Curved Top Chord
Santa Fe Single Track, North Span, Span 210'0"

Train Headed South
Bridge # 27
Records 911-940
Engine 1434



Train:- Engine 1434. Class 4-4-2. Kind:- Balanced Compound. Cars:- 5 Loaded & Coach. Date 7-31-08

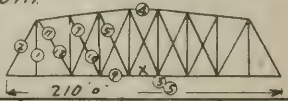
Instrument			Deflection			1				2				3				4				5				6				7				8	9				10				11				12			
Location			4th Pl Pt			Hip Vert Ins. South				So. End Post Ins. Top				Floor Beam 5th Pl Pt. So. Bot. Flge				3rd Diag Ins. Bar				3rd Diag. Outs Bar				Floor Beam 5th Pl. Pt. N. Bot. Flge				2nd Diag. Outs. Bar					Bot. Chd 4th Pl. Ins Bar				2nd Diag. Ins. Bar				Main Diag. Outs. Bar				Main Diag. Ins. Bar			
No	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
911	12	9.3S				39	39	0	I	43	36	19		30	29	3		28	27	4		37	37	0	M	32	28	14		51	48	6			37	37	0		37	33	12		57	56	2		56	56	0	
12	24		180	176	2	38			I	42		17		29		0		28		4		37		0	M	32		14		49		2	M		38		3		37		12	M	55			I	52			
13	28	4.0S	180		2	44		13		40		11		29		0	I	28		4		38		3	M	32		14		50		4	M		40		8		37		12	M	57		2	M	57		2	
14	28		178		1					41		14		30		3		30		11		36			M	31		11		49		2	M		40		8		36		9		56		0	M	58		4	
915	32	0.3N	186		6	42		8	I	42	35	20						28		4	M	38		3	M	32		14		48		0	M		40		8		36		9	M		55			58	55	5	I
6	36		187		6	47		20	I	40		14		32		10		29		7	M	38		3	I	31		11	I	48		0	M		38	36	6	I	35	32	9	I	60		9	M	60		9	
7	38		188	174	8	44		13	I	39		11		31		7	I	28		4	M	38		3	I	31		11		49		2	M		38		6	I	33		3	M	61		11		61		11	
8	46	3.0N	190	170	12	44		13		41		17		31		7	I	28		4	M	38		3	M	30		7	I	49		2	M		40		11		34		6	I	60		9	I	58		5	
9	37	2.2S	178	168	6	49		26		39		11	I	31		7	I	27		0		38		3	M	33		18		49		2	M		37		3		33		3		60		9	I	59		7	I
920	28	0.4N	180	180	0	46		18		39	36	8		32		10		28	27	4	M	38		3		29		4		48	48	0	M		34	37			33	33	0		58	56	4	I	55	56		M
1	27	1.2N	178	178	0	46		18	I	38		6		31		7		29		7	M	38		3	M	31		11		48		0	M		40		8		35		6		59		5	I	58		4	
2	33	2.0N	185		4	45		15	I	40		11		35		21		32		19	M	38		3	M	30		7	I	49		2	M		40		8		35		6	M	60		7	I	59		5	
3	32	6.6N	184	177	4	44		13	I	39		8		36		24	I	29		7	M	38		3	M	30		7	I	49	47	4	M		37		0	I	35		6	M	57		2	I	56		0	
4	31	5.5N	185		5	50		28		38	35	8		33		14		31		15	M	40		8	M	30		7	I	49		4	M		41	36	14		35		6	M	58		4	I	55			
925	47	9.4N	191	176	12	47		20	I	40		14	I	34		17	I	28		4	M	38		3	M	30		7	I	48		2	M		43		20	I	34	32	6	I	57	55	4	M	59	55	7	I
																						3rd Diagonal Ins. Bar 2/5 Pt from Bot																												
926	34	9.5S	183	174	5	44		13	I	38		9		34		17	I	30		11	M	60	56	7	I+	30		7	I	50	46	9	M+		40		11		33		3	M	57		4	M	62		13	
7	39	6.3S				43		10	I	37		6						31		15	M	63		12	I	31		11	I	50		9	M+		38		6	I	36		12	M+	61		11	M+	61		11	I
8	35	4.5S	178	168	6	45		15		39		11		32		10	I	35	26	35	M	62		11	I	32		14		48		4	M+		42	35	20	I	33		3	M	61		11		60		9	
9	17	2.1S	168	164	2	43		10		35	34	3		29		0		28		8		56		0		28		0		44	45				33				28				53				54			
930	40	1.6N	167		2	42		8		35		3	I	33		14	I	29		12	I	60		7	I	30		7	I	48		7	M		40		14	I	35	31	13	M	57	54	6	M	61	54	13	I
1	53	3.0N	177	160	11	50		28	I	35		3	I	29		0	I	30		15	M	63		12	I+	30		7	I	47		4	M		40		14	I	35		13	M	60		11	I	56		4	I
2	44	5.7N	176	159	11	42		8	I	37		9	I	29		0	I	30		15	M	56		0	I	30		7	I	47	44	7			38	34	12	I	33		6	I	65		20		62		15	
3	46	9.0S	179		13	42		8	I	37		9		30		3	I	30		15		57		2	I+	31		11	I	46		5	I		39		14		32		3	I	60		11		59		9	
4	42	5.2S	172	158	9	45		15	I	37		9		33		14	I	30		15	M	58		4	I	28		0		47		7	I		36		6	I	34		10	I	57		6	M	58		7	M
935	38	1.2S	164	157	4	45		15	I	36	33	9		32		10		25	25	0		52			I	29		4		45	43	5	I		35		3	I	33	30	10	I	56	53	6	M	56	53	6	I
6	33	1.0N	163	156	4	44		13	I	35		6		33		14		30		20	M	57		2	I	30		7		45		5	M		35		3		32		7	M	57		8		58		9	I
7	34	3.8N	167		7	44		13	I	35		6		34		17		30		20		58		4	I+	32		14		46		7	M		36	33	9		31		3	M	56		6	M	57		8	
8	36	6.4N	164		5	42		8	I	36		9		32		10		27		8		55			I	29		4		45	42	7	I		34		3		34		13		55		4	I	56		6	I
9	32	8.3N	166		6	43		10	I	35		6		34		17		27		8	M	58		4		28		0		46		10	M		34		3	I	30		0	M	56		6		56		6	I
940	40	8.0S	158		1	43		10	I	35		6		34		17		27		8	M	58		4	I	29		4	I	48		14	M		34		3	I	34		13	M	55		4	M	57		8	I

TABLE 6—ak.

Purcell, Okla. Through, Pin-Connected, Open Floor, Curved Top Chord.
Santa Fe. Single Track. N. Span. Span 210'.

Train:- Engine 1066. Class 2-6-2. Kind:- Compound. Cars:- 5 Loaded, Coach & Caboose.

Train Headed South.
Bridge # 27
Records 941-959
Engine 1066
Date 8-1-08.

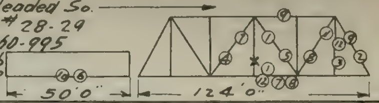


Instrument			Deflection			1				2				3				4				5				6				7				8	9				10				11				12			
Location			4th Pl Post			Hip Vert Ins South				S. End Post Ins Top				Floor Beam 5th Pl Pt. So Bot.				Top Chord Cent Pl. Ins Top				3rd Diag. Ins Bar				Floor Beam 5th Pl Pt. N. Bottom				2nd Diag Outs. Bar					Bot Chord 4th Pl. Ins Bar				2nd Diag. Ins Bar				Main Diag. Outs Bar				Main Diag. Ins Bar			
No	MPH	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
941	24					38	40		I	36	32	13		32	26	23		48	45	7		52	46	13	I	30	27	11			42				38	36	6	I	32	28	14		56	52	8	M	55	48	15	
2	26	0.45				50		25		36		13		29		12		50		11		53		15	I	27		0		48		14			38		6		29		4		59		13		54		12	
3	33	4.9N	189	162	17	40		0	I	38		19		25				57		27		57		24		29		7		51		21	M		42		17	I	30		7	M	60		15	I	55		15	
4	32	6.4N	196	161	22	42		5	I	38		19		26		0		60	44	36		54		17	I	31		15		49	41	19	M		45		25		34	27	26	M	59	50	18	I	55		15	
945	38	5.3S	173	160	8	40		0	I	39		22		31		19		49		11	I	51		11	I	36		33		45		10			40	35	14		32		19	I	50		0	M	53		10	
6	38	8.7N	170	159	7	48		20	I	37		16		31		19		47		7		54		17	I	33		22		45		10	M		39		11		32		19	M	54		8	M	54	46	17	
7	42	4.6S	168	158	6	47		18		42		31		28		8		53	43	23		50		9	I	35		30		45	40	12	M		37		6		30	26	15	I	53	48	10	M	50		9	
8	36	2.4S	186	157	18	38			I	34		6		31		19		54		26		54		17	I	32		19	I	45		12	M		39		11		31		19	M	58		21	M	52		13	
9	36	1.0N	173	156	11	40		0	I	35		9		30		15		57		33		58		26	I	28		4	I	46		15	M		38		9		32		23	M	54		12	I	48		4	
950	34	5.3S	193	164	18	41		2	I	37		16		32		23		55	45	22		54		17	I	33		22		46	42	10	M		40	36	11	I	31	28	11	M	64	52	23	M	55	48	15	
1	19	6.0S	173	163	6	36		0		38		19		27		4		48		7		48		4	I	28		4		43		2	M		36		0		28		0		52		0		48		0	
2	17	3.1S	166	162	2	43		8		34		6		26		0		48		7		52		13	I	28		4		43		2	M		35				28		0		52		0		49		2	
3	47	8.4S	181	161	12	49		22	I	42		31		31		19		54	44	23		54		17	I	30		11	I	46	41	12	M		40	35	14		30	27	11	I	55		6	M	53		10	I
4	42	5.4S	176	160	10	45		12	I	40		25		30		15		50		14		49		7	I	34		26	I	52		27	M		37		6		36		33	I	55	50	10	M	55	46	20	
955	32	4.5S	190	158	20	44		10		35		9		35		35		56		17		51		11	I	30		11		50		22	M		39		11		32		18		64		28	M	58		26	
6	34	7.0S	182	157	16	45		12	I	33		3		34		31		52	43	21		51		11	I	37		37			40				38	34	12	I		26			60		20	M	55		20	
7	38	2.5S	171		9	44		10		33		3		31		19		52		21		51		11	I	35		30	I	44		10	I		36		6		29		12	I	55		10	M	53		15	
8	38	6.5N	166		6	52		30		37		16	I	34		31		47		9		52		13	I	33		22							36		6		27		4		55		10	M	50		9	
9	15	7.1S	157		0	43		8		29				27		4		45	42	7		46		0		27		0		40		0			34		0		27		4		48	48	0		46		0	

TABLE 6—al.

Zyba, Kas. 2 Riveted Through, Open Floor, Single Track Warren Trusses. Span 124'0"
Rock Island. 2 Deck, Open Floor, Single Track, Plate Girders. Span 50'0"
Train:- Engine 1746. Class 2-8-0 Kind:- Simple. Cars:- Caboose, Coach & Private Car.

Train Headed So. →
Bridges # 28-29
Records 960-995
Engine 1746
Date 8-3-08



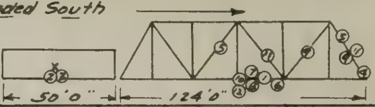
Instrument			Deflection			1						2				3				4						5				6				7						8				9				10				11				12			
Location			Cent of Span Truss			2nd Diag Ins Bot Edge						S End Post Ins Bot Edge				Hip Vert N Ins Edge				3rd Diag Ins. Top Edge						2nd Diag Out Top Edge				Plate Gird N. Span Ins Bot Flge				3rd Diag. Out Bot. Edge						Main Diag. Out Bot Edge				S End Post Out Top Edge				Plate Gird. N Span Out Bot Edge				Main Diag. Ins Top Edge				Hip Vert S. Out. Edge			
						Comp			Tens											Tens			Comp											Tens			Comp																							
No	MPH	CB	M	S	%E	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
960	22	715	86	80	8	36	35	3	24			39	33	18		48	42	14	I	27	25	8	34			47	40	18	I	43	39	10		13	12	8	34			39	39	0		29	25	16	I	48	42	14		58	52	12		26	24	8	
1	22	5.75	85		6	36		3	21			39		18		48		14	I	27		8	33			47		18	I	41		5		14		17	34			39		0		29		16		45		7		54		4		29		21	I
2	22	5.65	83	79	5	37		6	22			39		18		49		17	I	27		8	31			41		10		43		10		11			34			41		5		30		20		46		10		53		2		29		21	I
3	29	495	87		10	38		9	21			43		30	I	48		14	I	27		8	35			45		12	I	46		18	I	14		17	34			43		10	I	32		28	I	52		24	I	58		12		31		29	I
4	33	4.55	88	78	13	37		6	21			43		30	I	52		24	I	28		12	31			49		22	I	45		15	I	13		8	36			42		8		37		48	I	53		26		62		19		31		29	I
965	33	4.95	88		13	37		6	22			46		39		56		33	I	33		32	35			50		25	I	45		15		14		17	36			42	38	11		40		60		52		24	I	62		19		34		42	I
6	34	435	88		13	37		6	22			45		36		56		33	I	30		20	38			50		25	I	46		18		15		25	36			40		5	I	39		56		51		21	I	63	51	23		32		33	I
7	36	415	93		19	37		6	23			45	32	41		56		33	I	30		20	39			49		22	I	49		26		14		17	40			43		13		35		40		55		31	I	69		35		37		54	I
8	37	395	96		23	36		3	22			47		47		59		40	I	30		20	41			53		32		49		26	I	13		8	40			48		26		35		40						66		29		34		42	I
9	38	355	93	77	21	37		6	22			46		44						28		12	43			52		30		51		31		17		42	40			48		26		34	24	42		57		36		66		29		34		42	I
970	38	375	97		26	40		14	23			46		44		67		60	I	29		16	43			53		32	I	51		31	I	16		33	44			49	37	32		37		54		60		43		69		35		35		46	I
1	43	365	93		21	38		9	22			44		38		56		33	I	30		20	36			55		38	I	62		59	I	16		33	37			45		22	I	35		46		63		50		72		41		34		42	I
2	41	4.35	96		25	37		6	22			47		47		53		26	I	28		12	42			54		35	I	60		54	I	18		50	40			47		27		35		46	I	66		57	I	68		34		35		46	I
3	40	4.75	100		30	35		0	22			49	31	58		54		28	I	32		28	43			52		30	I	55		41	I	17		42	38			46		24		34		42	I	62		52	I	67	50	34		34		42	I
4	44	5.25	101	76	33	39		11	22			43		39		62		48	I	31		24	37			50		25	I	67		72	I	17		42	30			47		27		30		25	I	68		62		61		22		34		42	I
975	435	5.85	103		36	37		6	23			46		48		53		26	I	30		29	37			55		38	I	59		51	I	17		42	31			46	36	28		32		33	I	62		48		66		32		31		29	I
6	21	675	76	75	1	37		6	20			37		19		48		14	I	27		8	28			40		0	I	46		18	I	14		17	29			38		6		29		21		45		7	I	52		4		28		17	
7	11	665	76		1	35		0	15			33		6		41			I	25		0	28			39				39		0		14		17	25			36		0		27		12		42		0		50		0		25		4	
						Bot Chord 3rd Pl Ins Top																												Bot Chord 3rd Pl Outs. Bot.										Top Chord 3rd Pl Ins Top															
978	19	485	83	79	5	25	25	0	I			35	32	9		48	42	14	I	25		0	32			44		10	I	39		0	I	29	27	7	I			37	37	0	I	46	41	12		42		0		55	51	8		26		8	
9	27	345	85		8	27		8	I+			38		19		50		19	I	27		8	33			44		10	I	43		10	I	29		7	I			42		14	I	47		15		48		14	I	56		10		31		29	I
980	29	295	83	78	6	27		8	I			37		16		50		19	I	28		12	34			44		10	I	47		20		33		22	I			42		14	I	49		20		50		19		58		14	I	29		21	I
1	33	205	88		13	28		12	I			36		13		57		36	I	30		20	35			49		22		45		15	I	33		22	I+			39		5		52		27		55		31	I	60		18		28		17	I
2	32	185	84		8	27		8	I			36	31	16		56		33		26		4	36			49		22	I	47		20	I	30		11	I			39		5	I	48		17	I	50		19	I	60		18		28		17	I
3	35	135	90		15	28		12	I			37		19		54		28	I	28		12	37			54		35		45		15	I	30		22	I+			42		14		51		24		55		31		61		20		28		17	I
4	33	115	87	77	13	27		8	I			36		16		62		48	I	28		12	32			53		32	I	51		31		31	26	19	I+							49	40	22		48		14	I	64		26		29		21	I
985	36	0.75	94		22							38		23		57		36	I	29		16	37			53		32		49		26		33		27	I+							53		32		48		14	I	60		18	I	29		21	I
6	35	0.25	92		19	28		12	I			38	30	27		59		40		32		28	36			50		25	I	43		10	I	34		31	I+							52		30		52		24	I	65		27		31		29	I
7	36	095	94	76	24	29		16	I			38		27		65		55	I	27		8	37			53		32	I	47		20	I	33		27								53		32		52		24		62		22					
																																								Bot Chord 3rd Pl Ins Bot.																Bot Chord 3rd Pl Outs Top			
988	40	045	95		25	26		4	I			39		30		62		48		32		28	35			53		32	I	51		31	I	33		27	I			30	22	36		49		22	I	54		28	I	65	50	30	I	37	28	32	
9	39	045	95		27	29		16	I			39		30		63		50	I	30		20	37			51		28	I	47		20	I	32		22	I			27		23	I	54		35		52		24	I	69		38		39		29	
990	38	00	95		25	28		12	I+			38	29	31		66		57	I	30		20	36			52		30		47		20	I	32	25	28	I			27		23	I	53	39	36		51		21	I	64		28		36		29	
1	43	02N	97	75	29	30		20	I+			38		31		65		55	I	29		16	37			50		25	I	52		33	I	37		48	I			27		23	I	51		31	I	53		26		62		24	I	39		39	
2	46	01N	87		16	30		20	I+			35		21		58		38	I	31		24	34			54		35	I	47		20	I	34		36	I+			25	21	18	I	47		20	I	50		19	I	58		16	I	37		32	I
3	46	045	87		16	30		20	I			35		21		58		38	I	32		28	36			52		30		45		15	I	30		20	I+			25		18	I	47		20		53		26	I	58		16	I	37		32	I
4	47	085	84	74	14	27		8	I			32	28	14		55		31	I	31		24	36			54		35	I	50		28	I	33		32	I+			24		13	I	48		23		53		26	I	59		18		38		36	
995	15	255	76		3	27		8	I			30		7		44		5	I	24			28			44		10		39		0		25		0	I			21		0		42		8		42		0		53		6		28		0	

TABLE 6—am.

Zyba, Kas 2 Riveted Through, Open Floor, Single Track, Warren Trusses. Span 124'0"
Rock Island. 2 Deck, Open Floor, Single Track Plate Girders Span 50'0".

Train Headed South

Bridges 28-29
Records 996-1026
Engine 1746
Date 8-4-08



Train:- Engine #1746. Class 2-8-0. Kind:- Simple. Cars:- Caboose, Coach & Private Car.

Instrument			Deflection			1				2				3				4				5						6			
Location			Cent. of Span Girder			Bot. Chord 3rd Pl. Outs. Top				W. Plate Gird. N Span, Out. Bot. Flge				W. Plate Gird. N. Span, Ins. Bot. Flge				S. End Post Ins. Bot.				Diagonal 4th Pl. Ins. Top						W. Stringer 3rd Pl. Ins. Bot. Flge			
																						Tens.			Comp.						
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R
996	15	4.6N				44	43	2	I	38	35	9		34	35			47	43	9		24	26		39			48	48	0	I
7	21	5.4N	48	47	2	47		9	I	38		9	I	34				45		5		27		4	37			52		8	I
8	25	6.6N	54		15					40		14		42		20	I														
9	31	7.7N	55		17	46		7		45		29		44		26	I	48		12	I	28		8	38			54		12	I
1000	33	7.5S	57		21	48		12	I	43		23		43		23	I	49		14		28		8	40			56		17	I
1	37	6.7S	60		28	55	42	31		44		26		47		34	I	52	42	24		30		15	36			62		29	I
2	38	6.2S	62		32	55		31		57		63		53		51	I	53		26		38		15	44			65		35	I
3	40	5.9S	62		32	58		38	I	55		57		53		51	I	53		26		28		8	43			68		42	I
4	42	5.6S	69		47	56		33	I	55		57		57		63		52		24	I	31		19	42			66		37	I
1005	41	5.8S	64		36	55		31	I	55		57		53		51	I	54		28	I	30		15	41			65		35	I
6	44	6.0S	72		53	53	41	29	I	57		63		63		80		51		21	I	34		31	40			56		17	I
7	47	6.1S	73	46	55	55		34		56		60		63		80		46	41	12	I	31		19	38			58		21	I
8	45	6.5S	73		59	53		29	I	56		60		66		89		52		27	I	34		31	37			54		12	I
9	47	7.0S	73		59	52		27	I	58		66		65		86		50		22		29		11	35			47			I
1010	48	7.7S	77		67	52	40	30	I	59		68		61		74		49		20	I	30		15	34						
																												S. End F.B. S. Bot. Tens. Comp			
1011	49	8.1N	73		59	49		22	I	60		71		58		66		48		18	I	28		8	34			34	28	21	24
2	49	7.0N	70		52	49		22	I	63		80		57		91		47	40	18	I	28		8	31			34		21	24
3	45	6.2N	68		48	49		22	I	57		63		59		68		51		27	I	30		15	39			38		36	25
4	40	6.4N	63		37	46	39	18	I+	49		40		55		57		54		35	I	27		4	37			37		32	24
1015	38	6.4N	59		28	46		18	I	45		28		50		43		53		32		28		8	34			30		7	22
6	34	6.8N	56		22	44		13	I	47		34		49		40		50		25	I	28		8	32			29		4	24
7	17	6.2N	46		0	37	38			36		3		37		6		43		17		26		0	28			30		7	19
																						S. End Post Top Ins.									
1018	13	7.2S	47	47	0	34	36			36		3		34				40	40	0		41	40	3				29		4	18
9	20	3.0S	48		2	36		0	I	36		3		36		3		40		0		40		0				28		0	19
1020	20	3.8S	47		0	39		8	I	34				35		0		43		7		42		5				28		0	20
1	37	2.3S	55		17	45		25	I	39		11		44		26		48		20	I	46		15				38		36	26
2	49	1.3S	67		43	44	35	26	I+	43		23		47		34	I	41		2	I	40		0				37		32	21
3	38	2.6S	55		17	43		23		42		20		45		28		47		17		48		20				39		39	23
4	42	2.6S	60		28	44		16	I	40		14		54		54		48		20		50		25				40		43	23
1025	43	2.8S				44		26										47		17	I	50		25				41		46	23
6	43	4.0S				48		37	I									45		12	I	50		25							

Instrument			7				8				9				10				11						12			
Location			Bot. Chord 3rd Pl. Ins. Bot.				W. Stringer 3rd Pl. Out. Bot. Flge				Main Diag. Ins. Top				Floor Beam, Cent. Pl. Pt. S. Bot. Flge				Diagonal 3rd Pl. Ins. Bot.						Floor Beam Cent. Pl. Pt. N. Bot. Flge.			
																			Comp.			Tens.						
No.	M.P.H.	C.B.	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R
996	15	4.6N		24			49	45	9		61	62		I	31	31	0		33	33	0	17			41	38	8	
7	21	5.4N	26		8	I	53		18		62		0	I	35		13		35		6	17			40		5	
8	25	6.6N																										
9	31	7.7N	26		8	I	53		18		72		16	I	35		13		32			19			45		18	
1000	33	7.5S	27		12	I	50		11	I	74		19	I	36		16	I	38		15	17			44		16	
1	37	6.7S	27		12	I	56		24		79		27	I	39		26		39		18	19			46		21	
2	38	6.2S	26		8	I	57		27		85		37		42		35		36		9	22			50		31	
3	40	5.9S	32		39	I	70		56		78		26		42		35		42		24	20			50		31	
4	42	5.6S	28		21	I	65		44		76		23	I	44		42		42		24	16			51		34	
1005	41	5.8S	28		21	I	60		33		78		26	I	44		42		38		15	18			50		31	
6	44	6.0S	28		21	I	58		29		72		16	I	45		45		36		9	17			53		40	
7	47	6.1S	28		21	I	62		38		72		16	I	44		42		38		15	19			52		37	
8	45	6.5S	25		9	I	56		24		72		16		45		45		38		15	17			53		40	
9	47	7.0S	25		9	I	55		22		65		5	I	45		45		36		9	19			50		31	
1010	48	7.7S					45		0		65		5	I	45		45		35		6	20			53		40	
			S. End F.B. N. Bot. —Tension—																									
1011	49	8.1N	29	24	21	I	44				63		2	I	45		45		37		12	17			55		45	
2	49	7.0N	27		12	I	53		18		64		3	I	43		39	I	37		12	16			55		45	
3	45	6.2N	27		12	I	41				78		26		47		51								55		45	
4	40	6.4N	30		25	I	55		22		83		34		48		55								55		45	
1015	38	6.4N	28		17	I	51		13		74		19		43		39								47		24	
6	34	6.8N	26		8	I	49		9		81		31		44		42								46		21	
7	17	6.2N	24		0	I	49		9		63		2		34		10								38		0	
											S. End Post Outs. Top								S. End Post Outs. Bot.									
1018	13	7.2S	25		4		43				27	29			29	30			29	26	12				39		3	
9	20	3.0S	25		4		48		7		28				30		0		26						40		5	
1020	20	3.8S	26		8	I	50		11	I	30		3		33		10		29		12	I			45		18	
1	37	2.3S	32		12	I	61		35		43		48		40		33		40		54				49		29	
2	49	1.3S	30		25	I	55		22		33		14		35		17	I	32		23	I			43		13	
3	38	2.6S	36		50	I	60		33		42		45		38		27		40		54	I			48		26	
4	42	2.6S	30		17	I	60		33		41		41		40		33		38		46				48		26	
1025	43	2.8S	29		21	I	60		33		41		41		41		36		38		46				49		29	
6	43	4.0S	31		29	I					40		38						33		27							

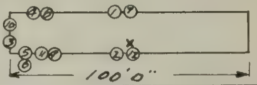
TABLE 6—an.

Alma, Kas. Through, Open Floor, Single Track, Plate Girder. Span 100'0"
Rock Island.

Train:- Engine #2200 Class 2-8-0. Kind:- Simple. Cars:- Caboose, Coach & Private Car.

Train Headed North

Bridge 30
Records 1027-51
Engine 2200
Date 8-5-08



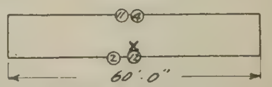
Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			1st Floor Beam So. of Cent of Span			Outs. Top Center				Outs. Bot. Center				N. Outs End End Stiff.				Ins Top 1/4 Point				N Bot. Flge Floor Beam 1st Pl. Pt. N. of C.				S Bot Flge Floor Beam 1st Pl Pt. N. of C.				Ins. Top Center				Outs Top 1/4 Point				Outs Bot. 1/4 Point				S Outs End Stiffener No. End				Ins Bot. 1/4 Point				Ins Bot. Center			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1027	11	2.6W	108							44	40	10						35	35	0		40	39	3		43	40	8						60	57	5		54	50	8		12	10	20		36	36	0					
8	9	2.5W	108							42		5		Ordinates too small to be read.				35		0		40		3		43		8						57		0		51		2		11		10						37	37	0	
9	11	2.4W	116	110	5					44		10						37		6		40		3		43		8						58		2		53		6		12		20		37		3		38		3	
1030	15	2.5W	113		3					43		8						37		6		39		0		45		12						58		2		57		14		11		10		39		8		40		8	
1	16	2.4W	114		4					43		8						38		9		39		0		48		20						59		4		55		10		12		20		41		14		38		3	
2	20	2.4W	114		4					44		10						38		9		41		5		48		20						59		4		55		10		11		10		42		17		40		8	
3	21	2.4W	116		5	62	56	11	I	43		8						38		9		43		10		48		20						63		11		56		12		12		20		44		22		40		8	
4	25	2.6W	117		6	59		5	I	44		10						39		11		43		10		53		32						61		7		58		16		13		30		44		22		41		11	
1035	25	2.6W	117	109	7	59		5	I	46		15						39		11		43		10		52		30						59		4		58		16		11		10		44		22		44		19	
6	27	3.6W	118		8	59		5	I	46		15						38		9		43		10		50		25	I					60		5		54		8		13		30		45		25		42		14	
7	30	3.7W	122		12	63		12	I	45		12						42		20		43		10		51		28	I					64		12		58		16		13		30		46		28		42		14	
8	33	3.8W	122	108	13	64		14	I	47		18						41		17		45		15		51		28	I					65		14		61		22		13		30		47		30		43		16	
9	34	3.8W	132		22	67		20		49		22						45		29		50		28		51		28						69		21		65		30		14		40		50		39		44		19	
1040	39	3.8W	142		32	73		30	I	54		35						50		43		53		36		59		48						76		33		72		44		16		60		53		47		49		32	
1	40	4.0W	156	107	46	70		25	I	56		40						48		37		52		33		60		50		63	45	40	I	75		32		73		46		16		60		53		47		48		30	
2	44	3.2W	146		36	68		21	I	57		42						48		37		53		36	I	63		58	I	59		31	I	72		26		71		42		14		40		53		47		49		32	
3	45	1.7W	133	106	25	63		12	I	53		32						49		40		48		23	I	59		48	I	58		29	I	70		23		68		36		13		30		54		50		48		30	
4	45	0.0	137		29	64		14	I	51		28						50		43		47		20	I	59		48	I	58		29	I	64		12		60		20	I	14		40		47		30		48		30	
1045	44	1.2E	139		31	64		14	I	51		28						53		51		48		23		57		42		58		29	I	70		23		63		26		14		40		48		33		47		27	
6	14	3.0E	110		4	54				41		2						39		11		43		10		46		15		46		2		57		0		50		0		10		0		38		6		37		0	
7	16	8.5E	110		4	58		4		41		2						38		9		45		15		48		20		49		9		58		1		52		4	I	10		0		39		8		39		5	
														W. Stringer Cent. Pl. Outs. Bot.																																							
1048	41	7.6W	143		35	72		29		54		35						48		37		47		20	I	55		38	I	66		47	I	72		26		65		30						54		50		50		35	
9	44	4.6W	133	105	27	68		21	I	52		30		53	37	36		46		32		49		26	I	58		45	I	58		29	I	74		30		64		28						48		33		46		24	
1050	12	3.1W	105		0	56		0		41		2		39		0		35		0		40		3		43		8		45		0		57		0		50		0						35				37		0	
1	41	3.0W	135		29	70		25		52		30		55		41		48		37		48		23	I	54		35	I	57		27		74		30		69		38						48		33		47		27	

TABLE 6—20.

McFarland, Kas. Through, Open Floor, Single Track, Plate Girder Span 60'0"
Rock Island.

Train:- Engine #2200. Class 2-8-0. Kind:- Simple. Cars:- Caboose, Coach & Private Car.

Train Headed North
Bridge 31
Records 1052-1079
Engine #2200
Date 8-6.08



Instrument			Deflection			1				2				3				4			
Location			3rd Pl Point from South							Ins Bot Center				N Bot Flge Floor Beam 2nd Pl Pt.				Outs Top Center			
No	MPH	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1052	11	7.6E	57	57	0					45	45	0		40	38	5		49	50		
3	19	7.5E	60		5					46		2		44		16		53		6	
4	21	74E	61		7					45		0		44		16		52		4	
1055	26	7.2E	60		5					47		4		40		5		55		10	
6	32	68E	61		7					51		13		43		13	I	56		12	
7	34	65E	66		16					54		20		48		26		59		18	I
8	35	66E	63		11					55		22		46		21	I	60		20	I
9	36	61E	69		21					54		20		47		24	I	61		22	I
1060	38	58E	68		19					55		22		49		29	I	60		20	I
1	41	66E	72		26					54		20		47		24	I	60		20	
2	37	39E	70		23					53		18		49		29	I	58		16	I
3	41	36E	75		32					55		22		46		21	I	58		16	I
4	43	4.0E	75	56	34					55		22	I	52		37	I	60		20	I
1065	43	4.2E	75		34					56		24		53		39	I	59		18	I
6	43^5	5.2E	77		38					56		24	I	48		26	I	59		18	I
7	44	64E	72		29					59		31	I	53		39	I	62		24	I
8	44	78W	72		29					62		38		47		24	I	64		28	I
9	12	66W	56		0					45		0		38		0		52		4	
1070	40	74W	73		30					63		40		46		21	I	63		26	I
1	37	72W	71		27					60		33		45		18	I	65		30	I
2	42	7.3W	73	55	33					62		38	I	48		26	I	66		32	I
3	40	7.5W	74		35					62		38		49		29	I	65		30	I
4	41	7.2W	75		36					60		33		49		29	I	66		32	I
1075	41	6.9W	77		40					60		33		46		21	I	68		36	I
6	12	59W	54	54	0					44				38		0		53		6	
7	17	6.2W	58		7					45		0		40		5		52		4	
8	38	7.0W	72		33					59		31						68		36	I
9	38	72W	71		31					61		35						68		36	I

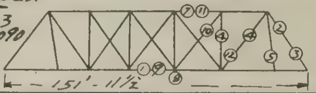
Instrument	5				6				7				8			
Location					Outs Bot W Stringer Cent Pl.				Ins Bot. W Stringer Cent Pl							
No					M	S	%E	R	M	S	%E	R				
1052					40	38	5		50	50	0					
3					39		3		51		2	I				
4					38		0		52		4	I				
1055					42		10		55		10	I				
6					44		16	I	58		16					
7					50		31	I	62		24	I				
8					48		26		64		28	I				
9					45		18	I	64		28	I				
1060					44		16	I	70		40	I				
1					45		18	I	71		42	I				
2					40		5	I	68		36	I				
3					44		16	I	71		42	I				
4					48		26	I	65		30	I				
1065					50		31	I	65		30	I				
6					53		39	I	64		28	I				
7					51		34	I	64		28	I				
8					58		51	I	58		16	I				
9					39		3		52		4					
1070					58		51	I	64		28	I				
1					55		45		63		26					
2					59		55	I	65		30	I				
3					58		51		64		28	I				
4					60		58	I	61		22	I				
1075					62		63	I	61		22	I				
6					37				52		4					
7					38		0		54		8					
8																
9																

Instrument	9				10				11				12			
Location	S. Bot. Flge Floor Beam 2nd Pl Pt.								Ins Top Center				Outs Bot Center			
No	M	S	%E	R					M	S	%E	R	M	S	%E	R
1052	51	50	2						52	50	4		43	43	0	
3	52		4						54		8	I	44		2	
4	52		4						59		18	I	43		0	
1055	54		8						54		8	I	45		5	
6	56		12						58		16	I	54		26	
7	58		16						60		20		55		28	
8	58		16	I					60		20	I	54		26	
9	54		8	I					61		22	I	54		26	
1060	57		14	I					61		22	I	55		28	
1	57		14	I					63		26	I	52		21	
2	55		10	I					58		16	I	50		16	
3	57		14	I					61		22	I	52		21	
4	58		16	I					62		24	I	53		23	
1065	58		16	I					63		26	I	54		26	I
6	58		16	I					67		34	I	55		28	I
7									62		24	I	58		35	I
8	58		16	I					66		32	I				
9	51		2						52		4		44		2	
1070	58		16	I					67		24	I	65		51	
1	57		14	I					67		34	I	61		42	
2	55		10	I					69		38	I	65		51	
3	59		18	I					69		38	I	65		51	
4	56		12	I					70		40	I	66		54	
1075	60		20	I					72		44	I	66		54	
6	50		0						50		0		42			
7	50		0						50		0		44		2	
8									74		48		62		44	
9									73		46		63		46	

TABLE 6—ap.

Sciotoville, Ohio. 1 Through, Skew, Pin-Connected, Open Floor, Suspended Floor Beams,
Norfolk & Western. Three Stringers, Single Track, Pratt Truss. Span 151'-11½"
1 Deck, Open Floor, Plate Girder, Single Track. Span 43'-0"
Train:- Engine 1059 Class 4-8-0 Frt. Kind:- Simple. Cars:- 5 Loaded, 1 Empty Box. & Caboose.

Train Headed East
Bridge 32-33
Records 1080-1090
Engine 1059
Date 8-10-08.

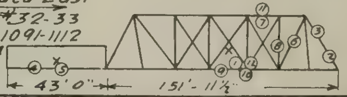


Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent. Pl. Pt.			Outs Bar, Ins Pr Bot Chd Cent. Pl.				Ins Top E End Post				Outs. Bot. E End Post				Outs Bar Main Diag.				Ins Bar Hip Vert.								Outs Top Top Chd 3rd Pl.				E Bot. Flge Floor Beam E Cent Pl Pt.				Ins Bar Out Pr. Bot Chd Cent. Pl.				Ins. Bar 2nd Diag.				Ins. Bot. Top Chd 3rd Pl.				Ins Bar Main Diag.			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1080	20		185	178	4	87	87	0	I	44	45			58	54	7		63	63	0	I									70	68	3						53	48	10	I	63	58	9	I	35	34	3		60	55	9	I
1	27		198	177	12	88		1	I+	48		7		58		7	I	66		5	I	74	69	7	I+					72		6	I					64		33	I	68		17	I	39		15		63		15	M
2	26		194	176	10	90		3	I+	45		0		60		11	I	68		8	I	72		4	I+					73		7	I					63		31	I	63		9	I	38		12	I	62		13	M
3	30		192	175	10	88		1	I+	48		7	I	62		15	I	70		11	I	74		7	I+					74		9	I					66		37	I	67		16	I+	37		9	I	65		18	
4	14		184		5	88		1	I	45		0		54		0		62			I	69		0	I					68		0	I			Records lost		48		0	I	58		0	I	34		0		56		2	M
1085	26	No C.B. Data	195		11					48		7		63		17	I	70		11	I+	70		1	I+					72		6	I					68		42	I+	73		26	I	35		3		63		15	I
6	30		184	174	6	87		0	I+	48		7	I	59		9	I	68		8	I+									71		4	I					62		29	I+	66		14	I	33				62		13	I
7	34		193	173	12	87		0	I+	48		7		59		9	I	70		11	I+									68		0	I					61		27	I	62		7	I	33			I	62		13	I
																		2nd Pl. Post E Ins.				S Stringer Cent. Pl. Ins. Bottom																															
8	36		194		12	90		3	I+	48		7	I	60		11	I	44	44	0	I	47	44	7	I					68		0	I					63		31	I					36		6	I	64		16	I
																																										S. Stringer Cent. Pl. Outs Bottom											
9	40		175		1	88		1	I+	45		0		59		9	I	44		0	I	49		11	I+					67			I					61		27	I+	52	52	0	I	34		0	I	58		5	I
1090	38		185	170	9	88		1	I+	45		0	I	60		11	I	44		0	I	44		0	I					70		3	I					64		33	I	52		0	I	34		0	I	60		9	I

TABLE 6—aq.

Sciotoville, Ohio. Through, Skew, Pin-Connected, Open Floor, Suspended Floor Beams.
Three Stringers, Single Track. Span 151'-11½"
Deck, Open Floor, Single Track Plate Girder Span 43'0"

Train Headed East
Bridges #32-33
Records 1091-1112
Engine 594
Date 8-11-08.



Train:- Engine #594. Class 4-6-2 Pass. Kind:- Simple. Cars:- 5 Loaded, 1 Empty Box & Caboose.

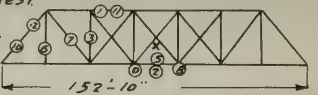
Instrument			Deflection			1				2				3				4				5				6			
Location			Cent. Pl. Pt.			Bot. Chord Cent. Pl./ Ins. Pr. Out Bar				E. End Post Bot. Outs.				E. End Post Top Ins.				Plate Gird. Bot. Ins. Flge.				Plate Gird. Bot. Outs. Flge.				Main Diag. Ins. Bar			
No.	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1091	8	7.2E	172	170	1					57	57	0		36	35	3		33	33	0		43	43	0		54	56		
2	21	4.5E	178	170	5					57		0	I	38		9		40		21	I	44		2	1	60		7	I
3	25	2.2E	175	169	4					60		5	I	35		0		43		30	I	52		21		63		13	I
4	28	5.9E	180	169	7					57		0	I	41		17	I				I	44		2	I	62		11	I
1095	32	2.0E	184	168	10					62		9	I	41		17	I	40		21	I	51		19	I	69		23	I+
6	36	5.2W	182	166	10					62		9	I	35		0	I	40		21	I	49		14	I	61		9	I
7	38	1.2E	184	165	12 Truss					67		18		41		17	I	43		30	I	48		12	I	63		12	I+
8	41	8.3E	181	164	10					58		2	I	40		14	I	38		15	I	70		63	I	60		7	I
9	44	1.0E	176	163	8					64		12	I	37		6	I	38		15	I	72		67	I	56		0	I+
1100	20	1.0W	176	163	8					58		2		36		3		39		18	I	50		16		56		0	I
Train:- Engine #1033 Class 4-8-0 Frt. Kind:- Simple. Cars:- 5 loaded, 1 Empty Box & Caboose.																													
1101	21		?							64	58	10		44	39	13		45	38	18	I	55	48	15	I	60	59	2	I
2	15	0.6W	?							63		9		43		10		38		0		53		10	I	60		2	M
3	18	2.6W	?							63		9	I	39		0		45		18	I	50		4	I	60		2	M
4	22	4.4W	?											42		8	I	42		11	I	56		17	I+	62		5	I
1105	28	8.6W	?							57			I	44		13		43		13	I	53		10	I+	60		2	I
6	33	4.3W								63		9	I	42		8	I	43		13	I+	53		10	I+	65		10	I
7	38	6.8W			Truss					63		9	I	41		5	I	47		24	I+	50		4	I	66		12	I
8	41	1.4W								63		9	I	40		3	I				I+	56		17	I	65		10	I+
9	42	4.2E	47	47	0					66		14	I	43		10	I				I+	46			I	65		10	I+
1110	45	4.4W	53		13	83	83	0	I+	66		14	I	41		8	I	48		26	I	58		21	I	62		5	I+
1	40	4.2E	51		9 Gird.	95		14	I+	58		0	I	45		15		49		29	I+	52		8					
2	16	4.2E	47		0	96		16	I	61		5	I	39		0		45		18	I	61		27		59		0	I

Instrument	7				8				9				10				11				12			
Location	Top Chord 3rd Pl. Ins. Bot.				2nd Pl. Post W. Ins.				Bot. Chord Cent. Pl./ Ins. Bar Out Pt.				Floor Beam E. Cent. Pl. Pt. W. Bot.				Top Chord 3rd Pl. Outs. Top				Floor Beam E Cent. Pl. Pt. E Bot. Flge.			
No.	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1091													78	70	11						31	31	0	
2					46	42	10	I					80		14	I					37		19	
3					45		7	I					75		7	I					36		16	
4					48		14	I					83		19	I					35		13	
1095					46		10	I					79		13						33		6	I
6					48		14	I					82		17	I					38		23	I
7					48		14	I					82		17	I					37		19	I
8					43		2	I					86		23	I					48		39	I
9					42		0	I					78		11	I					37		19	I
1100					46		10	I					74		6						35		13	
Train:- Engine #1033																								
1101					52	49	6	I	58	58	0	I	82	80	3	I						40		
2					52		6	I	68		17	I	90		13						40		0	
3					51		4	I	65		12	I	87		9	I					41		2	
4					50		2	I	69		19	I+	88		10	I					41		2	I
1105					51		4	I	69		19	I+	89		11	I					48		20	I
6					54		10	I	66		14	I	97		21	I					48		20	I
7					50		2	I	64		10	I	90		13						47		17.	I
8									70		21	I	88		10	I					50		25	I
9					56		14	I+					88		10	I					48		20	I+
1110					51		4	I+	72		24	I+	88		10	I					49		23	I+
1					46			I	71		22	I+	92		15	I					47		18	I
2					51		4	I	70		21	I	88		10						43		8	

TABLE 6—ar.

Waverly, Ohio. Through, Pin-Connected, Open Floor, Suspended Floor Beam
Norfolk & Western. Three Stringers, Single Track. Span 152'-10"
Deck Plate Girder on Viaduct Approach. Open Floor, Single Track.
Span 48'-0"
Train:-Engine #1059. Class 4-8-0 Frt. Kind:-Simple. Cars:-5 Loaded, 1 Empty Box & Caboose.

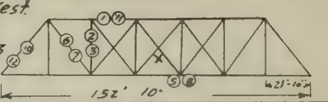
Train Headed West
Bridges 34-35
Records 1113-1153
Engine 1059
Date 8-12-08.



Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			4th Pl. Pt. Cent. of Gird.			Ins. Bot. Top Chd 5th Pl.				Bot. Flge So. Strger Cent. Pl.				W. Ins. Edge 2nd Pl. Post				Bot. Flge N. Pl. Girder				Outs. Bar Ins. Pair Bot. Chd. C. Pl.				Outs. Bar Hip Vert.				Ins. Bar Main Diag.				E. Bot. Flge Floor Beam 3rd Pl. Pt.				Bot. Ins. Flge Plate Gird. N. Gird. E. Span				Top Ins. Edge W. End Post				Top Outs. Edge Top Chd 5th Pl.				Outs. Bot. Edge W. End Post			
No.	R.P.M.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1113	15	3.3E	196	186	5	56	50	12	I	52	48	8	I	50	44	14		63	63	0	I	69	69	0	I	71	62	14	I+	70	70	0	I	69	65	6	I	43	43	0	I	46	42	10						59	58	2	
4	20	4.4E	190	185	3	53		6		58		21	I	46		5		70		11	I+	72		4	I	72		16	I+	70		0	I	68		5	I	50		16	I+	46		10						62		7	I
1115	22		202	184	10	56		12	I	60		25	I	49		11	I	70		11	I	72		4	I	79		27	I+	72		3	I	66		2	I	44		2	I	47		12	I					62		7	I
6	25	2.7W	204	183	11	53		6	I	48		0	I+	50		14	I	68		8	I+	76		10	I+	71		14	I+	72		3	I	67		3	I	50		16	I+	50		19	I					62		7	I
7	28	0.7W	199	182	9	53		6	I	50		4	I	53		20	I	73		16	I+	71		3	I	80		29	I+	74		6	I	70		8	I	51		19	I+	49		17	I					58		0	I
8	31	1.4E	195	181	8	53	49	8	I	64		33	I+	52		18	I	67		6	I+	74	68	9	I+	78		26	I+	75		7	I	75		15	I	45		5	I+	46	41	12	I					60		3	I
9	32	4.3E	190	180	5	52		6	I	66		37	I+	51		16	I	68		8	I+	78		15	I+	87		40	I+	75		7	I+	72		11	I	51		19	I	49		20						63	57	11	
1120	34	7.2W	198	179	11	50		2	I+	53		10	I	51		16	I	73		16	I+	72		6	I+	89		44	I+	69	68	1	I	74		14	I	53		23	I+	49		20	I					66		16	
1	37	2.9W	193	178	8	56		14	I+	55		15	I+	50		14	I	69		10	I+	74		9	I	85		37	I+					69		6	I	48		12	I+	48		17	I					60		5	
2	38	1.7W	198	176	13 Truss	57		16	I	50		4	I+	49		11	I	73		16	I+	80		18	I+								M/I	68		5	I	44		2	I+	47	40	17	I					60		5	
3	13	2.4W	178	174	2	48	48	0		50		4	I	43				66		5	I+	67	67	0	I	76		23	I	66			I	63				48		12	I	43		8						55			
4	40	5.3E	186	173	7	50		4	I	49		2	I	44		0	I	73		16	I+	71		6	I+	70		13	I+	70		3	M/I	70		8	I	48		12	I	44		10						63	56	13	I
1125	36	6.4W	187	172	9	50		4	I+	49		2	I+	48		9	I	70		11	I+	72		7	I	79		27	I+	70		3	M/I	67		3	I+	47		9	I+	44		10	I					61		9	I
6	40	0.1W	194	170	14	54		12	I+	50		4	I+	43			I	70		11	I+	76		13	I	76		23	I+	70		3	M/I	65		0	I	42			I+	44	39	13	I					58		4	I
7	36	4.9E	180	169	7	51		6	I+	48		0	I+	44		0	I	68		8	I+	73		9	I+	90		45	I+	70	66	6	M/I	80		23		49		14	I+	46		18	I					60		7	I
8	31	5.8E	182	167	9	53		10	I	63		31	I+	49		11	I	69		10	I+	71		6	I+	78		26	I+	70		6	I	70		8	I	48		12	I	43		10	I					63		13	
9	27	6.9W	176	165	7	50		4	I	60		25	I+	49		11		67		6	I+	75		12	I+	74		19	I+	70		6	I	67		3	I	47		9	I	44		13	I					58		4	
1130	25	6.6W	173	163	6	50		4	I	61		27	I	46		5	I	65		3	I+	72		7	I	76		23	I+					67		3	I	47		9	I+	46	38	18						59		5	
1	13	2.0E	68	68	0	50	50	0	I	53		10	I	43				64		2	I+	68	69			61			I+					65		0	I	43		0	I	42	41	2					Instrument out of adjustment	59	57	4	
2	18	0.9E	72		6	54		8	I+	56		17	I	50		14		69		10	I+	73		6	I	60			I+					70		8	I	47		9	I	43		5	I								
3	23	3.1W	78		15	53		6	I	55		15	I	47		7	I	67		6	I+	77		12	I	68		10	I+					70		8	I	50		16	I	44		7	I					70		23	I
4	27	2.3W	75		10	54		8	I	53		10	I+	47		7	I	67		6	I+	78		13	I									72		11	I	52		21	I+	44		7	I					60		5	I
1135	30	2.4W	75		10	54		8	I+	57		19	I+	50		14	I	68		8	I+	79		15	I+	72		16	I					74		14	I	53		23	I	43		5	I					62		9	I
6	33	5.2W	69		1	54		8	I	69		44	I+	49		11	I	66		5	I+	76		10	I+	85		37	I+					70		8	I	49		14	I+	47	40	18	I					70		23	I
7	36	6.6W	79		16	53		6	I	51		6	I+	49		11	I	68		8	I	75	68	10	I+	78		26	I+					76		17	I	50		16	I+	44		10	I					65		14	I
8	40	5.7E	76		12	53	49	8	I	52		8	I	48		9	I	75		19	I+	74		9	I+	73		18	I+	72	66	9	I+	72		11	I	48		12	I+	42		5	I					64	56	14	I
9	36	3.9E	79		16													74		17	I+																	52		21	I+												
1140	33	4.2W	77		13	57		16	I	62		29	I+	47		7	I	68		8	I+	70		3	I+	93		50	I+	68		3	I	69		6	I	47		9	I+	47		18						67		20	
1	28	3.0W	75		10					56		17	I+	45		2	I	72		14	I	74		9	I	75		21	I+	69		5	I	67		3	I	47		9	I	40	39	3	I					58		4	
2	26	1.3W	70		3 Girder					52		8	I+	53		20	I	68		8	I+	70		3	I	70		13	I+	67		2	M/I	70		8	I	47		9	I+	43		10	I					61		9	
3	24	0.8E	68	67	2	51		4	I	52		8	I+	45		2	I	66		5	I+	68	67	1	I	73		18	I+	67	64	5	I+	70		8	I	49		14	I+	44		13	I					64		14	I
4	22	2.2W	73		9					58		21	I	43			I	63		0	I	70		4	I	68		10	I+	60			M	68		5	I	49		14	I	40		3	I					63	55	14	I
1145	21	3.7E	72		7	50		2		57		19	I+	44		0	I	70		11	I+	66			I+	65		5	I+				M/I	68		5	I	48		12	I	42		8	I					58		5	
6	18	3.9E	72		7	47	48		I	57		19	I	45		2	I	63		0	I	69		3	I	67		8	I+				M/I	67		3	I	47		9	I									58		5	
7	11	3.4E	64			48		0	I	54		12	I	45		2		63		0		67		0	I	63		2	I+	60			I	65		0		43		0	I+	39	38	3						59		7	
8	31	6.0E	70		4	50		4	I	63		31	I+	46		5	I	67		6	I+	70		4	I	78		26	I+	62	62	0	I	65		0	I	46		7	I+	43		13	I					64		16	I
9	35	0.2W	72		7	50		4	I	58		21	I+	45		2	I	68		8	I	70		4	I	76		23	I+	66		6	I	70		8	I	50		16	I+	43		13						66		20	
1150	35	5.7W	77		5	50		4	I	58		21	I+	49		11		70		11	I+	70		4	I+	93		50	I+	63		2	I	70		8	I	44		2	I+	44		16						66		20	I
1	33	6.8W	83		24	57		19	I+	53		10	I+	53		20	I	66		5	I+	73		9	I	80		29	I+	68		10	M/I	74		14	I	48		12	I+	49		29	I					71		29	
2	35	5.4E	80		19	54		12	I	52		8	I+	53		20	I	72		14	I+	73	68	7	I	82		32	I	72	66	9	M/I	76		17	I	44		2	I+	46	41	12	I					68	56	21	I
3	13	4.7E	67		0	48		0		52		8	I	47		7		66		5	I	68		0	I	62		0		66		0	I	65		0		44		2	I+	43		5						60		7	

Waverly, Ohio. Through, Pin-Connected. Open Floor, Suspended Floor Beams.
Three Stringers Single Track. Span 152'-10"
Norfolk & Western. Deck, Open Floor, Single Track Plate Girder on Viaduct Approach
Span 48'-0"
Train:- Engine 603. Class 4-4-2 Pass. Kind:- Simple. Cars:- 4 Loaded, 1 Empty & Caboose. (3 Loaded-etc. after Rec 1167)

Train Headed West
Bridges 34-35
Records 1154-1183
Engine 603
Date 8-13-08



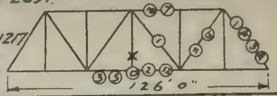
Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent of Gird. or 4th Pl. Pt.			Top Chord 5th Pl. Ins. Bot Edge				E. Outs. Edge 5th Pl. Post				W. Ins Edge 5th Pl. Post				N. Plate Gird. E. Span, Outs Bot. Flge				Floor Beam 3rd Pl. Pt. W. Bot. Flge				Main Diag. Outs. Bar				Main Diag. Ins. Bar				Floor Beam 3rd Pl. Pt. E. Bot. Flge				N. Plate Gird. E. Span, Ins. Bot Flge				W. End Post Ins. Top Edge				Top Chord 5th Pl Out Top Edge				W End Post Out Bot Edge			
No.	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1154	20	8.8E	64	56	14	52	50	4										48	44	9	I	39	33	18														40	38	5	I					60	59	2					
1155	10	8.9W	56		0	50		0	I	33	32	3		34	36			43			I	36		9		67	66	2	I	55	55	0	I	51	46	11		40		5	I	41	41	0		59		0		50	50	0	
6	15	8.0E	57		2	52		4		33		3	I	37		3		48		9	I	37		12		67		2	I	55		0	I	52		13		38		0	I	42		2		61		3		52		4	
7	20	3.7E	63		12	52		4	I	32		0	I	36		0	I	53		20	I	39		18		67		2	I	55		0	I	53		15	I	44		15	I+	44		7	I	62		5		54		8	
8	21	5.2E	64		14	51		2	I	32		0	I	37		3		50		14	I	40		21	I	67		2	I+	55		0	I	51		11	I	38		0	I	44		7	I	60		2		54		8	
9	25	5.7W	63		12	50	49	2	I	32		0	I	39		8		54		23	I	38		15	I	68	65	5	I+		54			55		20	I					46		12		63	58	9	I	52		4	
1160	28	1.9W	70		25 Girder	51		4	I	35	31	13	I	39	35	11		53		20	I	38		15	I	73		12	I+	58		7	I	54		17	I	39		3	I+	44	40	10	I	61		5	I	51	49	4	
1	30	10.2E	78		39	50		2	I	34		10	I	36		3		53		20	I+	38		15	I	67		3	I+	57		6	M I	51		11	I	43		13	I	42		5	I	63		9	I	51		4	
2	31	5.4W	78		39	50		2	I	32		3	I	35		0	I	65		48	I	42		27		67		3	I	57		6	M I	53		15	I	41		8	I	40		0	I	58		0		54		10	
3	36	4.7W	75		24	51	48	6	I	33		6	I	42		20	I	63		43	I+	40		21	I	69	64	8	I	57	53	8	I	54		17	I	39		3	I+	41		2	I	63		9	I	57		16	
4	38	0.3W	68		21	52		8	I	37	30	23	I	41	34	21	I	44		0	I	36		9	I	66		3	I+	56		6	M I	50		9	I	44		16	I	46	39	18	I	66	57	16		58	48	21	
1165	40	0.2W	78		39	52		8	I	37		23	I	41		21		50		14	I+	33		0	I	66		3	I	61		15	M I	52		13	I+	39		3	I+	43		10	I	63		11		60		25	
6	10	6.9W	56		0	45				28				37		9		47		7	I	36		9		61			I	54		2	I	52		13		40		5	I+	38				55				52		8	
7	44	8.2W	67		20	52		8	I	32		7	I	42		24	I	54		23	I	43		30	I	70		9	I+	57		8	M	53		15	I	38		0	I	44		13	I	62		9		57		19	
8	10	3.9W	174	178		49	48	2		26	30			36	34	6		43	44		I	36	33	9		65	65	0	I	55	54	2	I	52		13		38		0	I	38	41			58	58	0		53	50	6	
9	18	1.4W	184	178	3	48		0		30		0	I	39		15		52		18	I+	34		3		66		2	I	57		6	I	55		20		38		0	I+	38				59		2					
1170	19	8.0W	177	177	0	48		0	I	32		7	I	40		18		51		16	I+	33		0	I	66		2	I	54		0	M I	53		15	I	40		5	I	44		7		64		10		60		20	
1	22	1.6E	183	176	4	50		4	I	31		3		39		15		49		11	I	33		0	I	68		5	I+	54		0	M I	51		11	I	42		10	I	41		0	I	60		3		62		24	
2	24	9.9W	180	175	3	50		4	I	32		7	I	39		15		52		18	I+	33		0	I	66		2	I	54		0	M I	53		15	I	41		8	I+	44		7	I	60		3		57		14	
3	28	10.2E	182	174	5	51		6	I	31		3	I	35		3	I	52		18	I+	34		3	I	71		9	I	57		6	M I	54		17	I	47		24	I	40	40	0	I	61		5		56	49	14	
4	30	2.7E	178	173	3	48	47	2	I	33	29	14		36	33	9	I	54		23	I+	37		12		65	64	2	I+	55	53	4	M I	51		11	I	41		8	I+	41		2	I	60	57	5		56		14	
1175	36	4.6W	183	172	6	50		6	I	34		17	I	43		30	I	67		52	I+	38		15	I	67		6	I	56		6	M I	58		26	I	39		3	I+	44		10	I	61		7		61		24	
6	39	8.5W	182	170	7 Truss	48		2	I	35		21	I	41		24	I	51		16	I	41		24	I	70		9	I+	54		2	M I	58		26	I	38		0	I	41		2	I	60		5		59		20	
7	47	5.4W	182	168	8	52		11	I	32		10	I	39		18	I	49		11	I	47		42	I	75		17	I+	56		6	M I	59		28	I	46		21	I	42		5	I	62		9		59		20	
8	53	0.7E	186	165	13	49		4	I	39		34	I	45		36	I	47		7	I+	42		27	I	67		6	I+	56		6	M I	54		17	I	46		21	I+	41	39	5	I	60		5		58	48	21	
9	42	6.6W	184	164	12	48		2	I	37	28	32	I	44	32	37	I	52		18	I	39		18	I	69	63	10	I	55	52	6	M I	57		24		39		3	I	41		5	I	60	56	7		59		23	
1180	11	7.0W	164	164	0	46	46	0	I	28		0		35		9		50		14	I+	34		3		63		0	I	53		2	I	47		2		39		3	I	35				57		2		51		6	
1	38	8.4W	184	163	13	48		4	I	29		4	I	38		19	I	56		27	I				I	67		6	I+	54		4	M I	56		22	I	39		3	I	40		3	I	61		9		60		25	
2	42	1.4W	177	156	13	49		7	I	31		11	I	39		22		51		16	I	36		9	I	70		11	I+	53		2	M+	47		2	I	36			I	40		3	I	60		7		51		6	
3	42	9.8E	163	154	6	50		9	I	30		7	I	35		9	I	46		5	I+	41		24		61			I	54		4	M+	52		11	I	34			I	38	38	0	I	60		7		53	47	12	

TABLE 6—at.

Omega, Ohio Double Track, Skew, Through, Open Floor, Riveted, Warren Truss. Span 126'0"
Norfolk & Western.

Train:- Engine #603. Class 4-4-2 Pass. Kind:- Simple. Cars:- 3 Loaded, 1 Empty Box & Caboose.

Train Headed East.
Bridge 36
Records 1184-1217
Engine 603
Date 8-14-08



Instrument			Deflection			1				2				3				4				5				6			
Location			Cent. of Span			End Post Ins. Bot.				Bot. Chord 3rd Pl. Outs. Top				So. Stringer S. Trk. 4th Pl. Ins. Bot.				End Post Ins. Top				S. Stringer S Trk. 4th Pl. Outs. Bot.				Main Diag. Ins. Top			
No.	M.P.H.	L.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1184	9	1.0E	53	55		30	30	0		18	18	0		22	17	29		29	29	0		35	29	21		28	28	0	
5	17	2.2E	61		11	31		3	I	18		0		22		29	I	30		3		36		24	I	29		4	I
6	20	2.2E	58		5	33		10	I	20		11		22		29	I	32		10		36		24	I+	33		18	I
7	24	6.0E	56	54	4	30		0	I	20		11		25		47	I+	32		10		37		28	I+	37		32	I
8	27	4.6E	57		6	29	29	0	I	18		0	I	25		47	I+	32	28	14		36		24	I		27		
9	30	9.0E	56		4	31		7		19	17	12	I	23		35	I	29		4		38		31	I				
1190	32	7.2W	57	53	8	30		3	I	19		12	I	23		35	I	30		7		34		17	I	31		15	I
1	33	4.6W	55		4	29		0	I	19		12	I	22		29	I+	26				34		17	I+	31		15	I+
2	39	1.8E	55	52	6	30		3		20		18	I	19		12	I	29		4	I	34		17	I+	34		26	I+
3	40	5.2E	59		13	29		0	I	19		12	I	20		18	I	30		7		33		14	I	32		19	I
4	44	8.0E	58		12	33	28	18		20	16	25	I	23		35	I+	31	27	14		35		21	I+	35	26	35	I
1195	50	3.8W	63	51	24	32		14	I	20		25	I	20		18	I+	32		18	I	32		10	I+	32		23	I+
6	55	3.2E	58	50	16	28		0	I	19		19	I	24		41	I+	30		11	I	35		21	I+	33		27	I+
7	44	3.8E	58		16	31		11	I	20		25	I	24		41	I+	28		4	I	31		7	I+	31		19	I
8	34	8.0W	60	54	11	28	29		I	18	17	6	I	17		0	I	30	28	7		31		7	I		27		
9	44	1.3W	61		13	31		7	I	22		29	I	22		29	I+	29		4		34		17	I+	38		41	I
						Diagonal 3rd Pl. Top Ins.																							
1200	48	2.4E	65		20					20		18	I	26		53	I+	27				38		31	I	34		26	I+
1	38		59	53	11	30	29	3	I	18		6	I	20		18	I					31		7	I	31		15	I+
2	13	5.6E	53		0	29		0		16		0		20		18	I	26				29		0	I	25			I
3	44	0.8W	57		8	29		0	I	19		12	I	17		0	I	29		4	I	29		0	I+	31		15	I
1204	40	6.4W	56	52	8	29		0		18	16	12	I	17		0	I	32		14	I	29		0	I	31		15	I+
1205	38	76E	55	51	8	30		3	I	18		12	I	22		29	I	28	27	4	I	29		0	I+	31	26	19	I
6	45	2.6E	56	50	12	30		3	I	18		12	I	21		23	I+	32		19	I	29		0	I	30		15	I+
7	34	1.8E	52		4	27	28		I	16		0	I	24		41	I+	31		15		34		17	I+	30		15	I
8	31	0.1W	55		10	29		4	I	16		0	I	19		12	I	31		15		32		10	I	30		15	I+
9	35	4.0W	53		6	27			I	17		6	I	19		12	I	28		4	I	34		17	I	29		12	I
1210	38	3.2E	52		4	31		14	I	18		12	I	18		6	I	31		15	I	30		3	I	29		12	I
1	42	4.6E	60		20	30		7	I	18		12	I	19		12	I+	29		7		32		10	I	33		27	I+
2	46	2.0W	53	49	8	31		11	I	17	15	13	I	16	?	0	I	34	26	31		32		10	I+	31	25	24	I
3	58	0.2W	58		18	31	27	15	I	17		13	I	25		47	I	33		27		39		34	I	32		28	I+
1214	58	8.0W	54		10	31		15	I	18		20	I	32		88	I	32		23		54		86	I+	34		36	I+
1215	39	2.8W	53	48	10	25			I	16		7		16			I	28		8		26			I+	30		20	I
6	47	9.8W	54		12	33		22	I	17		13	I	24		41		32		23		34		17	I+	30		20	I+
7	13	4.8W	47	47	0	30		11		15		0		18		6		28		8		36		24		25		0	I

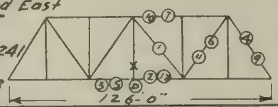
Instrument	7				8				9				10				11				12			
Location	Top Chord 3rd Pl. Ins. Bot.				End Post Outs. Top				End Post Outs. Bot.				Top Chord 3rd Pl. Pt. Outs. Top				Main Diag. Outs. Bot.				Bot. Chord 3rd Pl. Ins. Bot.			
No.	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1184	20	16	25		25	23	9						25	21	19						19	19	0	
5	21		31	I	24		4		12	13			22		5						19		0	
6	19		19	I	27		17		15		15	I	23		10		18	18	0		19		0	I
7	16		0	I	23		0	I	12			I	22		5		22		22	I	20		5	
8	17		6	I	25		9		14		8	I	21		0		21		17	I	20		5	I
9	18		12	I	27		17		15		15	I	23		10	I	21		17	I	20	18	11	
1190	18		12	I	26		13		14		8	I	23		10		22		22	I	21		17	I
1	17		6	I	23		0		13		0	I	22		5		21		17	I	19		6	
2	18	15	20	I	25	22	14	I	14		8	I	21	20	5		22		22	I	19		6	I
3	16		7	I	29		32		19		46	I	23		15	I	24		33	I	20		11	I
4	19		27	I	29		32	I	15		15	I	26		30		22		22	I	22	17	29	I
1195	21		40	I	30		36		18		38	I	24		20		26		44	I	20		18	I
6	20		33	I	23		5	I	12			I	20		0	I	22		22	I	19		12	I
7	21		40	I	28		27	I	16		23	I	24		20	I	22		22	I	20		18	I
8	21	16	31	I	27	23	17	I					23	21	10		25		39	I	23	19	5	
9	21		31	I	29		26	I	21		61	I	24		14	I	24		33	I	23		21	I
1200	20		25	I	34		48	I	20		54	I	24		14		26		44	I	20		5	
1	18		12	I	30		30		19		46	I	25		19		23		28		21		11	I
2	18		12						16		23		23		10		18		0		17			
3	20		25	I									23		10	I	23		28	I+	22		16	I
					3rd Pl Post East Inside																			
1204	20		25	I					15		15	I	22		5	I	22		22	I	21	18	17	I
1205	16		0	I	25	25	0	I+	19		46	I	25		19		22		22	I	22		22	I
6	18		17	I	30		20	I	20		54	I	27		29	I	23		28	I	19		6	I
7	17		6	I	32		28	I	16		23		22		5	I	22		22	I	18		0	I
8	17		6	I	31		24	I	17		31	I	22		5		22		22	I	20		11	
9	16	15	7	I	32		28	I+	15		15	I	22	20	10		20		11	I	20		11	
1210	19		27	I	25		0	I	18		38	I	22		10	I	23		28	I	20		11	I
1	18		20	I	30		20	I	18		38	I	26		30		20		11	I	19	17	12	I
2	18		20	I	27		8	I+	16		23	I	21		5		20		11	I	19		12	I
3	19		27		25		0	I+	18		38	I	22		10		21		17	I	20		18	I
					Lateral NE-SW 4th Panel																			
1214	18		20	I	10				17		31	I	22		10		20		11	I	20		18	I
1215	18		20	I	14				15		15	I	23		15		27		22	I	20		18	I
6	19		27	I	20				16		23	I	25		25		22		22	I	20		18	I
7	16		7		8				12								18		0		17		0	

TABLE 6—au.

Omega, Ohio Double Track, Skew, Through, Open Floor, Riveted Warren Truss. Span 126'0."
Norfolk & Western

Train:- Engine # 494. Class 4-8-0 Frt. Kind:- Simple. Cars:- 3 Loaded, 1 Empty Box & Caboose.

Train Headed East →
Bridge # 36
Records 1218-1241
Engine 494
Date 8-15-08



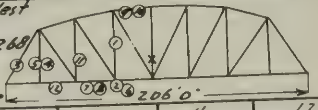
Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent of Span			Diagonal 3rd Pl Top Ins.				Bot. Chord 3rd Pl. Outs. Top				So. Stringr So Trk. 4th Pl. Ins Bot.				End Post Ins. Top				So. Stringer So Trk 4th Pl. Outs Bot.				Main Diag Ins. Top				Top Chord 3rd Pl Ins Bot.				Lateral N.E.—S.W. 4th Pl.				End Post Outs. Bot.				Top Chord 3rd Pl. Pt. Outs. Top				Main Diag. Outs. Bot.				Bot. Chord 3rd Pl Ins. Bot.			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1218	13	2.2E	60	59	2	34	34	0		19	19	0		28	25	12	I	35	34	3		39	34	15	I	33	33	0	I	19	19	0		8			I	19	19	0	I	21	21	0		15	18			20	20	0	
9	17	1.9E	63		7	35		3	I	23		21		31		24	I	34		0		41		21	I	33		0	I	20		5	I	11			I	20		5	I	24		14		18		0	I	21		5	I
1220	21	1.2E	61	58	5	38		12	I	20		5	I	29		16	I	37		9		39		15	I	33		0	I	19		0	I	10				18			I	23		10		19		6	I	21		5	
1	25	0.1E	67		16	36		6	I	21		10	I	30		20	I+	38		12		46		35	I	36		9	I+	21		11	I	10				20		5		28		33		22		22	I	22		10	
2	26	1.1W	62	57	9	39		15	I	23		21	I	32		28	I	37		9	I	45		32	I	34	32	6	I	20		5	I	9			I	19		0	I	25		19		22		33	I	23		15	I
3	30	2.3W	58		2	36		6	I	21		10	I	33		32	I	35	33	6	I	43		26	I	35		9	I	19		0	I	8			I	19	18	5	I	24		14		18		0	I	20		0	
																																		Floor Beam 3rd Pl. Pt. / Bottom Flge																			
1224	33	2.8W	60	56	7	35	33	6	I	19	18	6	I	32		28	I+	35		6	I	43		26	I	35		9	I	19	18	6	I					18		0	I	23	20	15		20	17	18	I	23	19	21	I
1225	37	3.4W	65	55	18	37		12	I	20		11		37		48	I+	35		6	I	40		18	I	35	31	13	I	19		6	I					19		6	I	24		20		23		35	I+	20		5	
6	40	3.5W	66	54	22	42		27	I	23		28	I	34		36	I+	38		15	I	39		15	I	37		19	I+	20		11	I	31	28	11		19		6	I	27		35		23		35	I	23		21	I
7	48	3.9W	60	53	13	35		6	I	22		22	I	32		28	I+	39		18	I	38		12	I	35		13	I+	20		11	I	28		0	I	21		17	I	26		30		21		24	I+	21		10	
8	43	3.7W	61	52	17	40		21	I	20		11	I	31		24	I+	40		21	I	37		9	I+	37		19	I+	20		11	I	28		0	·	23		28	I	25		25		21		24	I+	20		5	I
9	8	0.8W	52	52	0	33		0		18		0		25		0		28	32			34		0		30	30	0		17	17	0		22				20		11	I	20		0		18		6		18	18	0	
1230	39	2.8E	66	57	16	33		0	I					28		12	I+	40	34	18	I					34	33	3	I+	21	19	11	I	30		7	I	22	19	16	I	26	21	24		20	18	11	I	25	20	25	I
1	44	1.6E	63	57	11	41		24	I					27		8	I+	38		12		33			I+	39		18	I+	21		11		30		7	I	21		11	I	27		29	I	23		28	I	22		10	I
2	47	0.2W	63	56	12	40		21		20	19	5	I	30		20	I	38		12	I	38		12	I	34		3	I	21		11	I	32		14	I	22		16		26		24		23		28	I	20		0	I
3	50	3.0W	63	56	12	37		12	I	22		16	I	43		72	I+	42		24	I	43		26	I+	36	32	12	I+	21		11	I	35		25	I	20		5	I	25		19	I	22		22	I	20		0	
4	35	0.8W	60	55	9	34		3	I	20		5	I	31		24	I	35		3	I	42		24	I	34		6	I+	18	18	0	I	32		14	I	20		5	I	25		19		20		11	I	20		0	I
1235	34	1.1W	58	55	5	34		3	I	20		5		32		28	I+	35		3		40		18	I	33		3	I+	18		0	I	30		7	I	20		5	I	23		10		20		11	I	20		0	
6	39	4.3W	58	54	7	36	32	12	I	20	18	11	I	34		36	I+	37	33	12	I	34		0	I	35		9	I+	18		0	I	30		7	I	20	18	11	I	24	20	20	I	21	17	24	I	20		0	I
7	40	6.7W	62	53	17	35		9	I	21		17	I	29		16	I	40		21	I	36		6	I	35	31	13	I	19		6	I	32		14	I	20		11	I	24		20		21		24	I+	20		0	I
8	48	5.5E	64	53	21	33		3	I	20		11	I	33		32	I+	39		18	I	43		26	I	34		10	I+	20		11	I	30		7	I	18		0	I	25		25		22		29	I	21	19	10	
9	45	6.2E	66	52	27	32		0	I	21		17	I	33		32	I+	40		21	I	35		3	I	34		10	I+	21		17	I	32		14	I	19		6	I	26		30		20		18	I	19		0	I
1240	40	3.7E	61	51	20	34		6	I	19		6	I	30		20	I	40		21		35		3	I+	32		3	I	21		11	I	28		0	I	18		0	I	26		30		22		29	I	20		5	I
1	11	5.3E	56	51	10	33		3		18		0		25		0	I	32	32	0		35		3	I	28	30		I	18		0		28		0		19		6		18				17		0		16			

TABLE 6—av.

Niles, Ohio. Double Track, Through, Riveted, Open Floor, Four Stringers, Curved Top Chord. Pratt Truss. Span 206'0"

Penna Lines.

Train Headed West
Bridge 37
Records 1242-1268
Engine 7204
Date 8-17-08



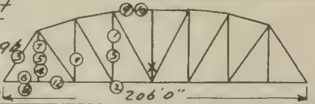
Train:- Engine #7204. Class 2-8-0 Frt. Kind:- Simple. Cars:- 5 Loaded, 1 Combination Coach & Caboose

Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent of Span			3rd Pl. Post W Outs.				Floor Beam 3rd Pl Pt W Bot Flge				W. End Post Ins Top				Hip Vert. E Ins.				Hip Vert. W. Outs.				Floor Beam 3rd Pl. Pt. E. Bot.				N. Outs. Strgr Flange Ins. Bot.				N. Ins Strgr Flange Outs. Bot.				Top Chord 4th Pl. Ins Bot.				Top Chord 4th Pl. Outs Top				2nd Pl Post W. Outs.				Bot. Chord 2nd Pl. Ins Top			
No	MPH.	CB	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1242	7	0.4E				22	22	0						16	16	0		35	38			6				16	18							28	28			19	19	0		20	20	0		22	21	5					
3	11	18E	70	70	0	24		9		14	14	0		16		0		38		0		7				18		0						33				19		0		20		0		20							
4	17	4.2E	76		9	25		14		15		7		20		25		41		8		10				18		0						34				20		5		22		10		21		0		11	12		
1245	20	6.7E	72		3	27		23	I	15		7		17		6		40		5		11				18		0						37			I	20		5		20		0		23		10		12		0	
6	26	4.3W	70		0	28		27		17		21	I	18		12		43		13	I	9				18		0						38			I	20		5	I	20		0		22		5		16		33	
7	27	0.2W	72		3					15		7	I	19		19		40		5	I	8				19		6						36			I	20		5	I	20		0		23		10		13		8	
8	30	4.4E	71		1	23		5	I	15		7		20		25		41		8	I	8				20		11		43	42	2	I	37			I+	21		11	I	22		10		26		24		14		17	
9	33	5.8W	71		1	25		14	I	15		7		21		31		43		13	I	9				20		11	I	51		21	I	39			I+	21		11	I	22		10		25		19		15		25	
1250	32	0.4E	73		4	24		9	I	16		14		21		31		42		10	I	8				20		11	I	49		17	I	40			I	20		5	I	21		5						15		25	
1	37	5.1W	70		0	27		23	I	17		21	I	20		25		45		18	I	8				20		11	I	47		12	I+				I+	20		5	I	20		0		25		19		13		8	
Two Cars Taken off																																																					
1252	36	4.5W	83(?)			27	21	29	I	17	14	21		19	16	19		43		13	I	9				20		11		43		2	I+	40			I+	24	19	26	I					26		24		14	11	27	
																						Hip Vert. W. Ins. Comp. Tens.																															
1253	40	3.3E	78		11	27		29	I	17		21		19		19		41		8	I	9		27		24		33	I	42		0	I	38			I+	21		17	I	23		15		26		24		15		36	I
4	43	2.7W	73		4	25		19	I	15		7	I	21		31		45		18	I	12		32		20		11		45		7	I	37			I+	21		17	I	20		0		29		38		17		54	I
1255	46	3.2W																																																			
6	47	5.1E	76		9	25		19	I	16		14	I	18		13		43		13	I	8		30		22		22	I	49		17	I	38			I	21		17	I	24		20		27		29		13		18	I
7	40	2.4E	71		1	25		19	I	18		28		22		38		42		10	I	8		29		23		28										21		17	I	24		20		31		47		12		9	
8	41	18E	70	69	1	27		29	I	17		21	I	20		25		39		3	I	11		27		20		11						36			I+	20		11	I	25		25		29		38		16		45	
																														N. Stringer S Rail, 3rd Pl. So. Bottom				S Stringer S. Rail - 3rd Pl. N. Bottom																			
1259	38	50W	72		4	28		33	I	17		21	I	21		31		46		21	I	8		31		22		22						24	23	4	I+	22		22	I	25		25		29		38		13		18	
																						Hip Vert. E. Outs.																															
1260	42	3.4W	74	68	8	27		29	I	15		7	I	21		31		47		24	I		11			20		11		57	53	8		28		22	I+	21		17	I	23		15		25		19		14		27	
1	41	1.6W	71		4	26		24	I	18		28		22		38		39		3	I	18		64		19		5	I	57		8	I+	28		22	I+	22		22	I	22		10		27		29		13		18	
2	38	70E	70		3	25		19	I	19		36	I	21		31		45		18	I	15		36		23		28	I	64		21	I+	25		9	I+	22		22	I	23		15		28		33		13		18	
3	39	3.8E	67	67	0	27		29	I	18		28	I	21		31		44		16	I	16		45	I	22		22		52			I+	33		43	I+	20		11	I	23		15		29		38		12		9	
4	37	4.6E	68	66	3	26		24	I	18		28	I	20		25		42		10	I	13		18	I	22		22		58		9	I+	26		13	I					23		15		29		38		13		18	
																														W. End Post Ins. Bottom																							
1265	12	6.8E	66		0	20				15		7						38		0		11		0		17				18	18	0		23		0		18		0		20		0		22		5		11		0	
6	37	4.2W	69		5	27		29		18		28		16		0		39		3	I	14		27	I	20		11		19		6	I	28		22	I+	23		28	I	23		15		24		15		13		18	
7	38	6.4E	67		2	25		19	I	17		21	I	16		0		42		10	I	14		27	I	23		28		20		11		27		17	I+	22		22	I	22		10		29		38		12		9	
8	39	6.6W	69		5	26		24	I	19		36	I	18		13		43		13	I	11		0	I	24		33		23		28	I	24		4	I	20		11	I	24		20		28		33		15		36	

TABLE 6—aw.

Niles, Ohio. Double Track, Through, Riveted, Open Floor, Four Stringers,
Penna. Lines. Curved Top Chord, Pratt Truss. Span 206'0"

Train Headed West
Bridge 37
Records 1269-1296
Engine 7027
Date 8-18-08



Train:- Engine # 7027 Class 4-4-2. Pass. Kind:- Simple. Cars:- 3 Loaded, 1 Combination Coach, & Caboose.

Instrument			Deflection			1				2				3				4				5				6				7						8						9				10				11				12			
Location			Cent. of Span			3rd Pl Post W. Outs. Compressn				Floor Beam 3rd Pl. Pt. W Bot. Flge				W End Post Ins Top				Hip Vert. E Ins				Hip Vert. W. Outs Edge				Floor Beam W. End, E. Bot. Flge				Hip Vert. W Ins.						Floor Beam W. End, W Bot Flge						Top Chd 4th Pl. Ins. Top				Top Chd 4th Pl. Ins Bot.				2nd Pl Pt. W Outs				Bot Chd 2nd Pl. Ins Top			
																														Comp			Tens			Comp			Tens																		
No	MPH	[illegible]	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1269	40	[illegible]	75	70	7	27	24	12		13	12	8		19	15	27		38	33	15	I					14	11	27	I	12			19	19	0	12			9	7	29					21	19	11		23	19	21		14	11	27	
70	14	58E	71		1	25		4		11				15		0		35		6	I	Readings small Plus & minus				13		18		8			19		0	11			6							19		0		22		16		12		9	
1	17	100E	72		3	25		4		12		0		17		13		35		6	I					11		0		8			20		5	8			8		14	31	29	7		19		0		20		5		12		9	
2	20	85W	71		1	25		4		12		0		17		13		37		12						12		9		8			20		5	10			7		0	31		7		20		5		19		0					
3	26	61W	73		4	25		4		13		8		18		20		37		12	I					15		36		10			20		5	11			8		14	31		7		19		0		20		5		13		18	
4	31	33W	75		7	24		0		14		17		18		20		36		9	I					11		0	I	10			20		5	10			9		29	32		10	I	21		11		22		16		16		45	
1275	33	02E	74	69	7	26		8	I	13		8	I	17		13		37		12	I					14		27		9			20		5	10			8		14	32		10	I	21		11		21		11		13		18	
6	38	50E	74		7	26		8	I	14		17	I	18		20		37		12	I					12		9	I	10			27		16	13			9		29	33	28	18		19	18	6	I	21		11		14		27	
7	40	75W	72		4	25		4		14		17	I	18		20		37		12	I					14		27	I	10			21		11	12			8		14	30		7		19		6	I	22		16		13		18	
8	43	15E	71		3	26		8	I	13		8	I	16		7		39		18						14		27	I	9			22		16	12			10		43	30		7	I	17				19		0					
9	43	85W	74		7	24		0		13		8	I	16	14	14																				13			10		43									23		21					
1280	44	43E	72	68	6	24		0	I	13		8	I	16		14		39		18	I					14		27	I	11			20		5	12			14		100	29		4		20		11		22		16					
																										Hip Vert. Ins West Comp Tens.																															
1281	49	97W	72		6	27		12		16		33	I	16		14		36		9	I	10		23 22	5	15		36	I	10						10			11		57	28		0		19		6	I	25		32					
																														Hip Vert Outs. West																											
1282	48	69W	71		4	29		21	I	14		17	I	17		21		36		9	I	10		27	23	13		18	I	Readings small						12			7		0	28		0		19		6	I	24		26		12		9	
3	52	76W	73		7	30		25	I	14		17	I	18		29		38		15	I	10		23	5	15		36	I							11			8		14	28		0		21		17	I	25		32		14		27	
4	58	80W	79	67	18	28		17		14		17	I	15		7		37		12	I	8		28	27	10			I							10			13		86	31	27	15		21	17	23	I	25		32		16		45	I
1285	57	97W	79		18	30		25		13		8	I	18		29		34		3	I	8		23	5	12		9	I							14			10		43	32		19		20		18	I	24		26		15		36	I
6	27	5.6E	70		4	24		0		13		8		15		7		32				10		20		12		9	I							8			7		0	26				17		0		19		0		13		18	
7	14	85E				25		4		13		8						33		0		6		22	0	10																24				17		0		18				11		0	
8	61	58[illegible]	81		21	24		0	I	14		17	I	19	15	27		37		12	I	8		27	23	12		9	I							11			7		0	29	28	4		22	18	22	I	23		21		14		27	I
9	66	9.6E	76	68	12	23			I	14		17	I	18		20		38		15	I	6		32	45	12		9	I							10			13		86	31		11		21		17	I	19		0		16		45	I
1290	44	9.2E	65		1	22			I	14		17	I	18		20		37		12	I	7		24	9	14		27	I							9			13		86	27				17				23		21		12		9	
1	46	7.0E	72		6	24		0	I	14		17	I	20		33		37		12	I	14		25	14	15		36	I							10			10		43	29		4	I	17				22		16		11		0	
																														Hip Vert. Outs. East																											
1292	47	43W	74		9	25		4	I	14		17	I					40		21	I			23	5	12		9	I	19	14			26	I+	10			8		14	28	27	4		19	17	12	I	25		32		11		0	I
																										3rd Pl Post Ins East																															
1293	48	[illegible]	[illegible]	[illegible]	10	24		0		14		17	I	16		7		40		21	I	Readings small				13		18	I+	20				31	I	8			14		100	26				19		12	I	22		16		13		18	I
4	49	[illegible]	[illegible]		9	25		4	I					16		7		36		9	I									18				21	I+							28		4		19		12	I	22		16		12		9	
1295	50	[illegible]	[illegible]		5	25		4	I					22		47		38		15	I									19				26	I+							28		4		20		18	I	25		32		12		9	I
6	17	2.6E	72		9	22								16		7		33		0	I									14				0	I							22				16				19		0		10			

TABLE 6—ax.

Wooster, Ohio. Four Track (5 Girders, 2 Light outside, 3 Heavy inside.) Through. Skew.
Penna. Lines. Ballasted Floor, Bar Floor Const. Plate Girders. Span 47'-10½" b. to b. Ls, 13'-6" c. to c. Girds.

Train Headed West
Bridges 38-39
Records 1297-1325
Engine 7204
Date 8-19-08.

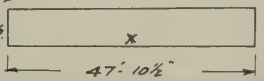
47'-10½"

Train:- Engine #7204. Class 2-8-0. Kind:- Simple. Cars:- 1 Loaded, 1 Combination Coach, 1 Caboose.

Instrument			Deflection			1				2				3	4				5	6				7				8	9				10				11				12			
Location			Cent. of Girders			Ins Gird. E. End So. Top				Outs Gird. W End Outs. Top					Ins. Gird. W. End N. Top					Ins Gird. W End So. Top				Ins. Gird. E. End N. Top					Outs Gird. E End Outs. Bot.				Outs Gird. W End Ins Top				Outs Gird. E End Outs. Top				Outs Gird E End Ins. Top			
No.	Speed	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R		M	S	%E	R		M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1297	14	0.4W	55	50	Outside Girder					22	21	5	I																9	9	0		23	20	15		20	18	11		19	18	6	
8	20	1.0E	55		10					23		10	I																10		11		24		20		19		6		18		0	
9	24	3.3E	55		10	18	18	0	I	23		10	I																10		11		23		15	I	20		11		19		6	
1300	26	6.4E	55		10	19		6	I	21		0	I																9		0		21		5		20		11		18		0	
1	31	3.7W	53		6					25		19	I																10		11		22		10	I	20		11	I	19		6	I
2	33	1.6E	54		8	19		6	I	24		14	I																9		0		22		10	I	19		6	I	21		17	I
3	35	0.7W	58		16	19		6	I	25		19	I							19	14	36	I	14	12	17	I		9		0		24		20		20		11	I	22		22	
4	37	7.0E	59		18	19		6	I+	23		10	I							17		21	I+	16		33	I		10		11		24		20	I	21		17	I	20		11	I
1305	38	0.2E	62		24	20		11	I	26		24	I+		18	15	20	I		19		36	I	14		17	I		10		11	I	24		20	I	20		11	I	22		22	I
6	40	5.0W	62	49	27	20		11	I+	27		29	I		17		13	I		18		29	I	16		33	I		12		33	I	25		25		23		28	I	21		17	I
7	40	4.0E	63		29	20		11	I+	25		19	I		18		20	I		20		43	I+	16		33	I		9		0	I	25		25	I	20		11	I	22		22	I
8	44	0.2W	65		33	20		11	I	26		24	I+		18		20	I		20		43	I	15		25	I		8				25		25		20		11	I	23		28	
9	44	4.4W	57		16	20		11	I+	23		10	I		17		13	I		18		29		16		33	I		10		11	I	25		25	I	21		17	I	20		11	I
1310	46	6.4E	60		22	20		11	I	26		24	I+		17		13	I		17		21		15		25	I		8				23		15	I	20		11	I	19		6	I
1	47	3.2E	67	48	40	20		11	I+	27		29	I		19		27	I		18		29	I	14		17	I		10		11	I	25		25	I	18		0	I	20		11	I
2	35	4.8W	60		25	19		6	I	25		19	I		16		7	I		15		7		16		33	I		11		22		23		15	I	19		6	I	20		11	I
3	40	4.8W	61		27	20		11	I	24		14	I+		16		7	I		17		21	I	15		25	I		10		11		22		10		18		0	I	21		17	I
4	41	4.2W	61		27	19		6	I+	26		24	I		16		7	I		16		14	I	14		17	I		11		22	I	25		25	I	22		22	I	23		28	I
1315	15	2.8W	53		10	18		0		21		0	I		12					14		0		12		0			10		11		20		0						19		6	
						Train on Second Track.																																						
6	49	No CB Data for 1-6	34	26	31 Inside Girder	15	13	15	I						20	15	33			17	12	42		11	10	10	I																	
7	11		27		4	13		0							15		0			13		8		9																				
8	38		32		23	15		15							18		20			16		33		11		10																		
9	43		32	25	28	16		23	I						18		20			17		42		12		20	I																	
1320	47		37		48	18		38	I						20		33			17		42		12		20																		
1	46		36		44	15		15	I						21		40	I		18		50		12		20																		
2	50		38		52	15		15							20		33			17		42		13		30	I																	
3	52		37		48	16		23							18		20			17		42		13		30																		
4	54		38		51	15		15							17		13			14		17		12		20	I																	
1325	11		27		8	12									15		0			12		0		10		0																		

TABLE 6—ay.

Wooster, Ohio Four Track (5 Girders, 2 Light outside, 3 Heavy inside) Through, Skew, Train Headed West →
Penna. Lines Ballasted Floor, Box Floor Const. Plate Girders. Span 47'-10½" b. to b. Ls, 13'-6" c. to c. Girds. Bridges # 38-39 Records 1326-36.
Engine 7027
Train:- Engine # 7027. Class 4-4-2. Pass. Kind:- Simple. Cars:- 1 Loaded, 1 Coach, 1 Caboose. Date 8-19-08.



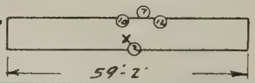
Instrument			Deflection			1				2				3	4				5	6				7				8	9				10				11				12			
Location			Cent. of Girds.			Ins. Gird. E. End So. Top				Outs. Gird. W. End Outs. Top					Ins. Gird. W. End N. Top					Ins. Gird. W. End So. Top				Ins. Gird. E. End N. Top					Outs Gird. E. End Outs. Bot.				Outs Gird. W. End Ins. Top				Outs Gird. E. End Outs Top				Outs Gird. E End Ins Top			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	P		M	S	%E	P		M	S	%E	R	M	S	%E	R		M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1326	78		36	27	33	14	10	40	I						16	13	23			13	9	44		9	9	0																		
7	7		25			10		0							13		0			9		0		9		0																		
8	44		28	26	8	12		20	I						18		38	I		12		33		10		11																		
9	50		30		15	12		20	I						16		23			12		33		9		0																		
1330	52		33	25	22	13		30	I						16		23			14		56		10		11	I																	
1	59		30	24	25										18		38	I		14		56	I				I																	
2	14		50	46	9					23	22	5			12	12	0												10	8	25		21	20	5		17	17	0		16	15	7	
3	39	4.5E	52		13					23		5	I+		14		17	I											9		12		22		10	I	17		0	I	16		7	
4	42	7.3W	48	45	7					22		0	I+		14		17	I											8		0	I	20		0	I+	17		0	I	15		0	
1335	47	1.0E	53		18					22		0	I+		14		17	I											8		0	I	20		0	I	17		0		16		7	I
6	47	5.4W	49	44	11					24		9	I+		14		17	I											8		0	I	20		0	I	17		0	I	15		0	I

Ins. Gird. ← → Outs. Gird.

TABLE 6—az.

Winona Lake, Ind. Double Track, Skew, Ballasted Floor, Box Floor Construction,
Penna. Lines. Plate Girders, (1 Heavy-center, 2 Light-outside) Span 59'2" b.to b. L's, 13'c.to c. Girds.

Train Headed West
Bridge #40
Records 1337-1359
Engine 7204
Date 8-20-08.



Train:-Engine #7204. Class 2-8-0 Frt. Kind:-Simple. Cars:-1 Loaded & Coach.

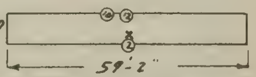
Instrument			Deflection			1	2				3	4	5	6	7				8	9	10				11	12			
Location			N. Girder Cent. Span				Outs. Bot. N. Girder								Outs. Top N. Girder						Ins. Top N Girder					Outs. Top N. Girder			
No.	M.P.H.	C.B.	M.	S.	%E		M	S	%E	R					M	S	%E	R			M	S	%E	R		M	S	%E	R
1337	8	0.4W	39	39	0		29	29	0						32	30	7				30	27	11						
8	11	0.2W	40		3		29		0						30		0				27		0						
9	15	0.2W	40		3		30		3						32		7				27		0						
1340	18	0.2E	44	38	16		30		3						30		0				26	26	0						
1	28	2.8E	45		18		30		3						34		13												
2	31	5.0E	42		11		30		3						34		13				31		19						
3	33	7.2W	42		11		30		3						32		7				29		12						
4	37	4.0W	44		16		30	28	7						30		0				29		12						
1345	39	0.0	47		24		33		18												33	25	32						
6	41	4.7E	45	37	22		35		25												32		28						
7	41	4.2W	47		27		35		25												29		16			27	25	8	
8	43	2.2E	53		43		37		32												31		24			32		28	
9	45	5.7W	50		35		36		29												32		28			30		20	
1350	46	0.8E	51		38		38		36												34		36			34		36	
1	51	6.0W	51		38		38		36												30		20			37		48	
2	49	1.4E	53		43		39	27	43												35	24	46			35		40	
3	60	0.8W	53	36	47		39		43												33		38			34	24	42	
4	55	6.2W	52		44		38		39												30		25			32		33	
1355	52	1.0E	52		44		35		29												34		42			34		42	
6	57	1.0W	55		53		39		43												33		38			32		33	
7	56	3.0W	55		53		39		43												27		12			34		42	
8	64	1.2W	55		53		39		43												35		46			32		33	
9	14	1.5W	38		6		27		0												24		0			24		0	

TABLE 6—ba.

Winona Lake, Ind. Double Track, Skew, 1 Heavy-center, 2 Light-outside, Ballasted Floor,
Penna. Lines. Box Floor Construction, Plate Girders. Span 59'-2" b. to b. Ls, 13 c. to c. Girds.

Train:- Engine # 7027. Class 4-4-? Pass. Kind:- Simple. Cars:- 1 Coach

Train Headed West
Bridge # 40
Records 1360-90
Engine 7027
Date 8-20-08
8-21-08

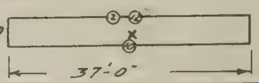


Instrument			Deflection			1	2				3	4	5	6	7	8	9	10				11	12			
Location			N. Girder Cent. Span				Outs. Bot. N. Girder											Ins. Top N. Girder					Outs. Top N. Girder			
No.	M.P.H.	C.B.	M	S	%E		M	S	%E	R								M	S	%E	R		M	S	%E	R
1360	13		36	33	9		26	25	4									22	22	0			23	20	15	
1	15	60E	35		6		26		4									23		5			20		0	
2	22	84W	36		9		25		0									23		5			20		0	
3	33	87E	37		12		27		8									25		14			22		10	
4	38	96W	43		30		32		28									25		14			25		25	
1365	42	77W	41		24		29		16									25		14	I		23		15	
6	44	60W	39		18		27		8									23		5	I		22		10	
7	47	45W	41		24		28		12									21	21	0	I		23		15	
8	52	3.0W	42		27		31		24									24		14	I		25		25	
9	13	21W	33		0		24	24	0									21		0			19	19	0	
1370	9	94E	30	30	0		24		0									28		33			26		37	
1	43	78W	35		17		24		0									26		24			25		31	
2	51	24W	38		27		26		8									30		43			28		47	
3	50	18W	39		30		28		17									29		38			28		47	
4	52	00	40		33		29		21									30		43			30		58	
1375	57	00	42		40		29		21									30		43			32		68	
6	60	77E	36		20		25	23	9									28	20	40	I		36	18	100	
7	63	69W	43		43		28		21									27		35	I		33		83	
8	64	88W	40		33		25		9									26		30			32		78	
9	64	76W	40		33		26		11	I								26		30			30		67	
1380	71	3.5W	49		63		35		53									30		50	I		37		106	I
1	74	3.9W	53		77		33		44									30		50	I		36		100	
2	81	39E	47		57		33		44									27		35			35		95	
3	81	72E	43		43		32	22	46									25		25			32		78	
4	87	0.8E	53		77		35		49									33		65	I		36		100	
1385	92	22W	58		93		30		36	I								29	19	53	I		32	17	88	
6	100	13E	70		133		37		68									34		79	I		46		170	
7	75	3.1W	51		70		34		55									30		58			37		118	I
8	68	21E	42		40		34		55									28		47			34		100	I
9	76	79E	38		27		30		36									24		26			29		70	I
1390	13	58E	31		3		20	21										19		0			23		35	

TABLE 6—bb.

Plymouth, Ind. Double Track, Skew, 2 Girders, Ballasted Floor, Box Floor Const.
Plate Girders 37' b. to b. end Ls., 26' c. to c. Girders.
Train:- Engine #7204 Class 2-8-0 Frt. Kind:- Simple. Cars:- 1 Loaded & Coach.

Train Headed West
Bridge #41
Records 1391-1410
Engine 7204
Date 8-21-08

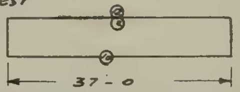


Instrument			Deflection			1	2				3	4				5	6	7	8	9	10				11	12			
Location			3' West of Center				Ins. Top Center					Floor Trough									Outs Bot. Center					Outs. Top Center			
No	M.P.H.	L.B.	M	S	%E		M	S	%E	R		M	S	%E	R						M	S	%E	R		M	S	%E	R
1391	10		17	15	13		21	18	17												25	20	25			28	23	22	
2	14		16		7		18		0												22		10			25		9	
3	20		18		20		21		17												24		20			25		9	
4	25		18		20		23		28												25		25			26		13	
1395	29		17		13		20		11												20		0			24		4	
6	32		17		13																23		15			22			
7	35	1.3W	20		33		24		33												26		30			26		13	
8	36	6.8W	19		27		24		33												26		30			28		22	
9	39	1.8W	19		27		24		33												25		25			26		13	
1400	42	4.8E	20		33		25		39												28		40			30		30	
1	45	2.6W	18		20		24		33												24		20			26		13	
2	45	4.6E	21		40		24		33			28	18	56							28		40			32		39	
3	46	1.2W	19		27		24		33			27		50	I						25		25			28		22	
4	50	2.6W	20		33		24		33			25		39	I						25		25			29		26	
1405	52	6.9W	21		40		26		44			25		39	I						27		35			29		26	
6	57	6.0E	24		60		26		44			27		50	I						26		30			31		35	
7	64	6.6E	25		67		31		72	I		25		39	I						30		50			32		39	
8	11	5.1E	17		13		18		0			17									20		0			23		0	
9	17	6.4E	18		20		20		11			18		0							23		15			25		9	
1410	20	6.4W	18		20		19		6			18		0							23		15			24		4	

TABLE 6—bc.

Plymouth, Ind Double Track, Skew, 2 Girders, Ballasted Floor, Box Floor Construction,
Penna Lines Plate Girders. 37' b. to b. end L^s, 26' c. to c. Girders.
Train:- Engine #7451 Class 4-4-2 Pass. Kind:- Cole Balanced Compound. Cars:- 1 Coach.

Train Headed West
Bridge #41
Records 1411-23
Engine 7451
Date 8-22-08.

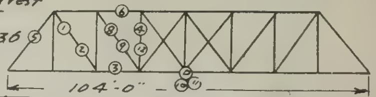


Instrument			Deflection			1	2				3	4	5	6				7	8	9	10				11	12			
Location			3' W. of Cent.				Ins. Top Center							Floor Trough							Outs Bot. Center					Outs Top Center			
No.	M.P.H.	C.B.	M	S	%E		M	S	%E	R				M	S	%E	R				M	S	%E	R		M	S	%E	R
1411	11		15	14	7		11	11	0												18	17	6			11	10	10	
2	24		15		7		14		27												19		12			11		10	
3	34		16		14		15		36												18		6			14		40	
4	42		17		21		15		36												19		12			15		50	
1415	46	[illegible]	16		14		16		46					24	18	33	I				17		0			15		50	
6	50		16		14		15		36					23		28	I				20		18			15		50	
7	54		17		21		16		46					22		22	I				23		35			17		70	
8	61		18		29		18	10	80					24		33	I				22		29			20		100	
9	68	[illegible]	19		36		17		70	I				26		44					23		35	I		20		100	
1420	84		18		29		15		70	[illegible]				26		44	I				22		29			18		80	
1	75		17		27		15		50					32		78	I				25		47			16		60	
2	15½	[illegible]	14		0		6							17							18		6			9			
3	17		15		7		10		0					18		0					17		0			8			

TABLE 6—bd.

Plymouth, Ind. Double Track (2 Trusses) Open Floor, Riveted Pony Truss
Penna Lines.
Span 104' 0"

Train Headed West
Bridge #42
Records 1424-36
Engine 7451
Date 8-22-08



Train:- Engine #7451 Class 4-4-2 Pass. Kind:- Cole Balanced Compound. Cars:- 1 Loaded, 1 Coach.

Instrument			Deflection			1				2				3				4			
Location			Cent. of Span			Ins. Top Main Diag				Ins. Bot. Main Diag.				Ins. Top Bot. Chd 3rd. Pl.				Ins. W. Edge 3rd Pl. Post			
No.	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1424	13		50(?)			24	24	0		21	21	0		10	10	0		Ordinates too small to be read			
25	20		62	54	15	27		13		24		14		10		0					
6	28		61		13	29		21		25		19		12		20					
7	38		68		26	29		21	I	25		19	I	12		20					
8	42		75		39	29		21	I	26		24									
9	54		74	53	40	25		4	I	26		24	I	11		10	I				
1430	58		62		17	25		4	I	26		24	I	12		20	I				
1	46		73		38	26		8	I	26		24	I	13		30					
						Hopper Car taken off															
2	14		55		4	23	23	0		21	21	0		10	10	0					
3	62					25		9	I	25		19	I	12		20					
4	67		60	52	15	24		4		25		19	I	13		30					
1435	78		62		19	25		9	I	26		24	I	13		30	I				
6	10±					23		0		21		0		9							

Instrument			5				6				7				8			
Location			Ins. Top W. End Post				Ins. Top Top Chd 3rd Pl				Bottom Floor Trough				Ins. Top 2nd Diag.			
No.	M.P.H.	C.B.	M	S	%E	R	M.	S	%E	R	M	S	%E	R	M	S	%E	R
1424	13		26	25	4		21	21	0						22	22	0	
25	20		27		8	I	21		0						22		0	
6	28		26		4	I	26		24						23		5	
7	38		27		8	I	26		24						25		14	
8	42		28		12	I	32		52						28		27	I
9	54		28		12	I	32		52						24		9	I
1430	58		28		12	I	29		38	I	18	14	29	I	23		5	I
1	46		25		0	I	28		33		17		21	I	24		9	
2	14		22	22	0		22	22	0		14		0		22		0	
3	62		26		18		25		14	I	19		36	I	24		9	I
4	67		27		23	I	26		18	I	22		57	I	24		9	I
1435	78		28		27	I	26		18	I	15		7	I	22		0	I
6	10±		23		5		24		9		13		0		22		0	

Instrument			9				10				11				12			
Location			Ins. Bot. 2nd Diag.				W. Bot. Flge Floor Beam Cent. Pl. Pt.				E. Bot. Flge Floor Beam Cent. Pl. Pt.				Outs. W. Edge 3rd Pl. Post			
No.	M.P.H.	C.B.	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1424	13						11	11	0						Ordinates too small to be read			
25	20		22	20	10		12		9		17	17	0					
6	28		24		20		12		9		18		6					
7	38		23		15	I	13		18		19		12					
8	42		25		25		14		27		24		41	I				
9	54		20		0		12		9	I	22		29	I				
1430	58		20		0	I	14		27	I	18		6	I				
1	46		23		15	I	15		36		21		23	I				
2	14		19	19	0		13	11	18		16	16	0					
3	62		21		11	I	14		27	I	16		0	I				
4	67		21		11	I	14		27	I	20		25	I				
1435	78		20		5	I	14		27	I	20		25	I				
6	10±		19		0		11		0		16		0					

TABLE 6—bc.

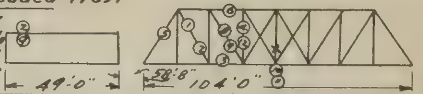
Plymouth, Ind. 1 Double Track (2 Trusses) Open Floor, Riveted Pony Truss. Span 104'-0"

Penna. Lines. 1 Double Track, 2 Girders, Ballasted Floor, Bar Floor Const. Span 49' b. to b. Ls, 26' c. to c. Girds.

Train:- Engine #7027 Class 4-4-2 Pass. Kind:- Simple. Cars:- 1 Coach.

Train Headed West

Bridges 42-43
Records 1437
Engine 7027
Date 8-22-08

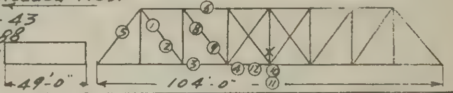


Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent. of Spans			Ins. Top Main Diag.				Ins. Bot. Main Diag.				Ins. Top. Bot. Chd 3rd Pl.				W. Ins. 3rd Pl. Post				Ins. Top W. End Post				Ins. Top. Top Chd 3rd Pl.				Floor Trough				Ins. Top 2nd Diag.				Ins. Bot. 2nd Diag.				W. Bot. Flge Floor Beam Cent. Pl. Pt				E. Bot. Flge Floor Beam Cent. Pl. Pt.				Outs West 3rd Pl. Post			
No.	MPH	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1437	11		51	50	2					20	20	0										24	19	26						13	13	0		22	22	0		19	19	0		10	10	0		16	16	0					
8	28		57		14	25	20	25	I	23		15	I	12	9	33						26		37		23	24			13		0		23		5		19		0		12		20		18		12					
9	38		60		20	24		20		23		15	I	12		33						27		42	I	26		8		15		15		26		18		25		32	I	12		20		21		31					
1440	42		62	49	26	25		25	I	24		20	I	12		33						25		32		26		8		14		8		23		5		25		32		12		20		19		19	I				
1	45		60		22	26		30	I	22		10	I	12		33						26		37		25		4		13		15	I	25		14		23		21	I	12		20		19		19	I				
2	49		55		12	25		25	I	22		10	I	11		22						28		47	I	25		4		16		23	I	25		14	I					13		30		23		44	I				
3	52		55		12	25		25	I					11		22						29		53	I	24		0		15		15	I	24		9						11		10	I	19		19	I				
4	57		60		22	25		25	I					11		22						25		32		25		4		15		15		25		14						14		40	I	22		38	I				
	8-24-08																																																				
[illegible]	9		50	48	4	21	21	0						9		0		20				19		0		25	25	0		14		8		24		9						12	15			15				22			I
[illegible]	12	23W	50		4	22		5						9		0		20			I	21	20	5		29		16		14		8		22		0		20	20	0	I	15		0		15				22			I
[illegible]	46	70W	54		12	25		19	I	18			I	9		0					I+	25		25		30		20	I	14		8	I	23		5		21		5	I	16		7	I	19		19	I				H
6	48	57E	55		15	26		24	I	20				10		11					I+	26		30		29		16	I	18		38	I	24		9		23		15		16		7		18		12					H
[illegible]	51	91E	56		17	25		19	I	18			I	11		22					I+	26		30		30		20	I	16		23	I	25		14		23		15	I	16		7	I	18		12	I				H
[illegible]	[illegible]	2.8W	62		29	28		33	I	22		10		12		33					I+	24		20	I	30		20	I	17		31	I	25		14		20		0	I	16		7	I	20		25	I				I+
[illegible]	[illegible]	21W	62		29	25		19	I	21		5	I	12		33					I+	25		25	I	30		20	I	20		54	I	25		14	I	21		5	I	14			I	23		44	I				I+
[illegible]	[illegible]	25E	72		50	26		24	I	25		25		13		44						25		25	I	29		16	I	26		100		30		36		22		10	I	18		20	I	25		56	I				
[illegible]	[illegible]	75E	63		31	27		29		23		15	I	13		44	I					26		30	I	33		32	I	26		100		26		18		22		10	I	18		20	I	20		25	I				
[illegible]	[illegible]	92E	64		33	24		14	I	25		25	I	13		44						27		35	I	33		32	I+	21		62	I	23	21	10	I	20		0	I	19		27		18		12	I				
[illegible]	[illegible]	5.7W	60	47	28	28		33	I	25		25	I	13		44						28		40	I	30		20	I	21		62		23		10	I	24		20	I	16		7	I	22		38	I				
0	14	7.0W	63		34	26		24	I	25		25	I	13		44	I					26		30	I	30		20	I	24		85		24		14	I	24		20	I	15		0	I	20		25	I				
[illegible]	11	0.7W	66		40	27		29	I	26		30	I	14		56	I					25		25	I	35		40	I	25		92		27		28	I	22		10	I	17		13	I	19		19	I				
8	58	01E	63	46	37	25		19						14		56						25		25	I	33		32	I	29		123		28		33						19		27	I	23		44	I				
9	59	4.3W	60		30	24		14						10	8	25	I					25		25		32	24	33	I	25		92		25		19		20	18	11	I	18	15	20	I	19	15	27	I				
1460	11	38E	46		0	20	20	0		16	14	14		8		0						19	19	0		28		17		13		0		21		0		18		0		17		13		15		0					
1	10	19W	22	20	10	20		0		14		0		8		0						18				27		12		12				22		5		18		0		15		0		15		0					
2	48	22E	22		10	24		20	I	15		7		12		50						25		32	I	29		21		16		23	I	23		10		20		11	I	15		0	I	19		27	I				
3	58	66E	22		10	27		35		18		29		12		50						27		42	I	30		25	I					25	20	25		18		0	I	16		7	I	18		20	I				
4	45	78E	23		15	25		25		16		14		10		25						21		11		30		25	I	13		0		25		25		19		6		16		7		17		13					
1465	62	91W	25		25	22		10	I	18		29		12		50						23		21	I	30		25	I	20		54		23		15	I	20		11	I	15		0	I	25		67	I				
6	63	62W	25		25	26		30	I	24		71		11		38						23		21		29		21	I	24		85		27		35		24	17	41	I	16		7	I	25		67	I				
7	66	38W	29		45	24		20	I	27		93		9		13						22		16	I	27		12	I	25		92		26		30	I	21		24		20		33		22		47	I				
8	70	04E	29		45	23		15	I	17		21		9		13	I					26		37	I	32		33	I	25		92		24		20	I	20		18		18		20		20		33	I				
9	81	92W	27		35	25		25	I	25		79		11		38	I					25		32	I	32		33	I	24		85		23		15	I	21		24		15		0	I	20		33	I				
1470	11	95E	21		5	19	19	0		13				7	7	0						19		0		27		12		13		0		19	19	0		17		0		15		0		15		0					

TABLE 6—bf.

Plymouth, Ind. Double Track, (2 Trusses) Open Floor, Riveted Pony Truss. Span 104'0".
Penna Lines. Double Track, 2 Girders, Ballasted Floor, Box Floor Const. Span 49' b. to b. L.s 26' c. to c. Girders
Train:- Engine #7204. Class 2-8-0 Frt. Kind:- Simple. Cars:- 1 Coach.

Train Headed West
Bridges 42-43
Records 1471-88
Engine 7204
Date 8-24-08



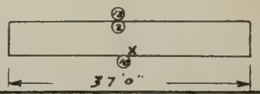
Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Cent. of Span			Main Diag. Ins. Top				Main Diag. Ins. Bot.				Bot. Ch'd Ins Top 3rd Pl.				N. Stringer N. Pair So. Bot. Flge				W. End Post Top Ins.				Top Chord 3rd Pl Ins Top				Floor Trough				2nd Diag. Ins. Top				2nd Diag. Ins Bot.				Floor Beam Cent. Pl. Pt. W. Bot. Flge				Floor Beam Cent. Pl. Pt. E. Bot. Flge				So. Stringer 4th Pl. N. Pr. N. Bot Flge			
No.	M.P.H.	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1471	10	3.3E				23	21	10						10	9	11						22	23			32	30	7						25	24	4						14	15			18	17	6					
2	8	4.0E	24	24	0	22		5		15	14	7		9		0						23		0		32		7						25		4		18	18	0		15		0		17		0					
3	22±	6.9W	28		17	25		19	I	15		7		10		11					I+	26		13		33		10		17	15	13	I	25		4		20		11		18		20		21		23					I+
4	38	3.4W	30		25	28		33		20		43		11		22					I+	32		39		37		23		18		20		27		12		21		17		18		20		23		35					I+
1475	47	2.9E	34		42	28		33		23		64		11		22					I+	31		35		36		20		24		60		28		17		25		39		21		40	I	21		23	I				I+
6	52	5.2W	35		46	26		24	I	23		64		11		22					I+	26		13	I	35		17		23		53		28		17	I	23		28		18		20	I	24		41	I				I+
7	53	1.8E	34	23	48	26		24	I	26		86		15		66						33		43	I	33		10	I	23		53		28		17	I	25		39		20		33	I	21		23	I				
8	58	3.2W	37		61	27		29	I	22		57		13		44						30		30		32		7		23		53		25		4	I	25		39		18		20	I	27		59	I				
9	62	6.1W	36		57	25		19	I	20		43		12		33						29		26	I	35		17	I	28		87		24		0	I	26		44		17		13	I	23		35	I				
1480	75	4.9W	38		65	30		43	I	24		71		14		55						31		35		33		10	I	28		87		26	23	13		25		39		18		20		24		41					
1	10	6.6W	23		0	23		10		17		21		10		11						23		0		30		0		15		0		24		4		18		0		16		7		17		0					
2	9	3.8E	47	47	0	21		0		15		7		11		22						23		0		30		0		15		0		25		9		18		0		16		7		17		0					
3	35	6.8W	55		17	25		19		19		36		10		11						26		13		32		7		18		20		26		13		20		11		19		27		20		18					
4	38	2.4W	57		21	24		14		16		14		12		33						29		26		35		17		20		33		24		4		21		17		18		20		18		6					
1485	42	2.9E	63		34	26		24	I	20		43		13		44						30		30		37		23	I	21		40		29		26		23		28		17		13		24		41	I				
6	50	4.1W	60	46	30	24		14	I	24		71		13		44						28		22		32		7	I	19		27		30		30		23		28		20		33	I	26		53	I				
7	47	0.8E	68		48	28		33	I	17		21		14		55						28		22		34		13	I	19		27		28		22		21		17		20		33		22		29	I				
8	13	18E	50		9	22		5		14		0		9		0						24		4		30		0		15		0		21				18		0		17		13		16							

TABLE 6—bg.

Plymouth, Ind. Double Track, Skew (2 Girders) Ballasted Floor, Box Floor
Penna. Lines Construction, Plate Girder. 37'0" b. to b. Ls., 26'0" c. to c. Girders.

Train:- Engine #7027. Class 4-4-2. Pass. Kind:- Simple. Cars:- 1 Coach.

Train Headed West
Bridge #41
Records 1489-1512
Engine 7027
Date 8-25-08.

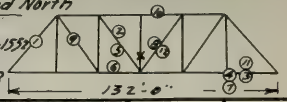


Instrument			Deflection			1	2				3	4	5	6				7	8	9	10				11	12			
Location			3'W. of Cent. of span				Center Ins. Top							Floor Trough							Center Outs. Bot.					Center Outs. Top			
No.	M.P.H.	C.B	M	S	%E		M	S	%E	R				M	S	%E	R				M	S	%E	R		M	S	%E	R
1489	8	6.6E	13	12	8		18	18	0					18	18	0					15	15	0			17	18		
1490	15		13		8		17							18		0					17		13			15			
1	26		15		25		20		11					18		0					17		13			18		0	
2	32	1.6E	16		33		22		22					20		11					17		13			15			
3	36	1.8W	15		25		20		11					19		6					16		7			22		22	
4	39	8.0E	13		8		20		11					19		6					16		7			18		0	
1495	43	6.6W	13		8		22		22					23		28					15		0			19		6	
6	46	1.6W	13		8		19		6					28		56					16		7			22		22	
7	49	5.7E	14		17		18		0					26		44					18		20			21		17	
8	51	4.9W	13		8		20		11					25		39					15		0			22		22	
9	54	4.4W	13		8		22		22					26		44					15		0			21		17	
1500	58	9.7W	16		33		21		17					27		50					22		47			23		28	
1	60	2.6W	16		33		19		6					29		61					19		27			28		56	
2	66	2.7E	19		58		23		28					36		100					23		53			30		67	
3	66	9.7W	14		17		22		22					39		117					17		13			22		22	
4	70	2.5W	16		33		20		11					35		94					28		87			25		39	
1505	76	5.7E	22		83		24		33					34		89					26		73			33		83	
6	77	6.1E	22		83		24		33					34		89					25		67			31		72	
7	82	5.3W	16		33		22		22					41		128					24		60			29		61	
8	75	4.5W	17		42		20		11					26		44					24		60			23		28	
9	77	2.0E	27		125		25		39					40		122					27		80			34	19	79	
1510	80	4.0W	18		50		23		28					38		111					28		87			26		37	
1	14	5.0W	14		17		19		6					19		6					16		7			19		0	
2	10	5.0W	14		17		19		6					18		0					15		0			19		0	

TABLE 6—bh.

Savanna, Ill. Single Track, Through, Pin-Connected, Open Floor, Pratt Truss. Span 132'0"
C. B. & Q.

Train Headed North
Bridge #9
Records 1513-1552
Engine 2703
Date 8-26-18



Train:- Engine #2703. Class 4-4-2. Kind:- Balanced Compound. Cars:- 2 Loaded & Caboose

Instrument			Deflection			1				2				3			
Location			Cent. of Span			End Post Ins. Top				Diagonal 3rd Pl. Ins. Top				W. Stringr 6th Pl., N. Bot. Flge			
No.	MPH.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R
1513	11	2.3N				47	47	0		43	44						
4	14	3.0N				47		0						43	41	5	
1515	19	5.5N												43		5	I
6	21	6.8N				47		0.		44		0	I	43		5	I
7	24	2.6S	147	142	4	47		0	I	45		2		43		5	I
8	28	6.7S	149		5	49		4	I	45		2		44		7	I
9	30	3.3N	150		6	48	46	4	I	44		0	I				
1520	34	1.3N	151		6	49		7		48		9	I	43		5	I
1	38	9.1N	162		14	49		7	I	50		14		47		15	I
2	42	10.2N	153		8	48		4	I	55		25		59		44	I
3	47	4.6N	155		9	49		7	I	64		46		63		54	
4	14	3.1N	146		3	46	45	2		43	43	0		43		5	
1525	17½	4.2N	155	141	10	50		11	I	43		0		44		7	
6	19	1.3S	165		17	50		11	I	48		12		40			
7	22	8.2S	142		1	47		4		45		5		41		0	I
8	24	10.0N	145		3	46		2		46		7	I	48		17	I
9	25	9.4S	142	140	1	46		2	I	48		12		42		2	I
1530	16½	9.2S	146		4	45	44	2		49		14		44		7	
1	17	9.8N	147	139	6	46		5		46		7	I	48		17	
2	17½	5.8N	149		7	48		9	I	49		14	I	45		10	
3	19	0.2S	162	138	17	52		18		49		14	I	42		2	I
4	20	2.0S	153		11	46		5						41		0	I
1535	22	6.4S	142	137	4	43	43	0	I	46		7	I	43		5	I
6	15	3.1S	156	148	5	45	45	0		46	44	5					
7	16	5.4S	154		4	48		7		48		9	I	42		2	I
8	18	9.9S	153	147	4	46		2		48		9	I	44		7	
9	19	8.8N	150		2	47		4		48		9		45		10	
1540	20	7.6N	155	146	6	49		9		48		9	I	47		15	
1	21	6.1N	156		7	49		9	I	49		11	I	42		2	I
2	22	4.2N	152	145	5	48		7	I	47		7		46		12	I
3	25	2.4N	144		3	47		4		49		11	I	40			I
4	30	3.7S	151	144	5	48		7	I	51	43	19	I	48		17	
1545	34	8.4N	152		6	44	44	0	I	49		14	I	47		15	I
6	37	6.4N	153	143	7	47		7		53		23	I	46		12	I
7	40	3.6N	150		5	47		7	I	58		35		48		17	I
8	44	9.7N	148	142	5	48		9	I	69		61		52		39	
9	46	5.3N	156		10	48		9	I	68		58		65		58	
1550	52	1.1S	152	141	8	46		9	I	64		49		80		95	
1	53	8.5S	157		11	51		16	I	69		61		88		115	
2	10	5.7S	142	140	1	44		0		43		0		44		7	

Instrument	4						5				6				7				8					
Location	Floor Beam 5th Pl. Pt. N. Bot. Flge						Diagonal 3rd Pl. Outs. Bot.				Bot. Chord 3rd Pl. Top Outs.				Floor Beam 5th Pl. Pt. S. Bot. Flge				Diagonal 4th Pl. Ins. Top					
	Eng.			Car															Comp.			Tens.		
No.	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E
1513	49	49	0	49	49	0	48	48	0						37	35	6	I	30	26	15	36		
4	54		10	53		8	51		6		36	34	6	I	37		6		27		4	39		
1515	52		6	54		10									37		6							
6	53		8	52		6	52		8		34		0	I	42		20	I	28		8	43		
7	50		2				53		10						39		11		30		15	42		
8	50		2	52		6	51		6						39		11		32		23	44		
9	52		6				52		8						40		14	I	29		12	47		
1520	50		2				52		8						36		3	I	26	25	4	41		
1	49		0	55		12	54		12		45		32	I	37		6	I	36		44	50		
2	54		10	57		16	62		29		40		18	I	37		6	I	25		0	44		
3	56		14	62		27	75		56		41		21	I	39		11	I	30		20	58		
4	52		6				47	47	0		39	33	18	I	38		9		25		0	37		
1525	53		8								37		12	I	37		6		27		8	36		
6	53		8				48		2		40		21	I	39		11		29		16	45		
7	52		6				49		4		35		6	I	37		6	I	27	24	12	38		
8	51		4								36		9	I	40		14	I	27		12	43		
9	52		6								37		12	I	40		14		30		25	38		
1530	51		4				48		2		34		3	I	37		6	I	24		0	44		
1	50		2				47		0		34		3	I	39		11	I	24		0	43		
2	50		2				40				36		9	I	39		11	I	26		8	42		
3	50		2				53		13		37		12	I	40		14	I	28		17	44		
4	51		4				52		11						39		11	I				42		
1535	51		4								34		3	I	41		17	I	25		4	42		
6	50		2				43	47			40	34	18	I	35		0	I	24		0	45		
7	51		4				48		2		37		9	I	38		9		24		0	42		
8	51		4				51		9		39		15	I	39		11	I	24		0	47		
9	54		10				52		11		40		18	I	41		14	I	25		4	44		
1540	53		8				56		19		36		6	I	38		9	I	27		12	47		
1	54		10				57		21		38		12	I	40		14	I	29		21	48		
2	52		6				53		13		36		6	I	39		11	I	25		4	47		
3	56		14				50		6		35		3	I	39		11	I	28		17	40		
4	54		10	55		12	57	46	24		37	33	12	I	38		9	I	30	23	30	42		
1545	52		6	55		12	53		15		43		30	I	36		3	I	27		17	44		
6	55		12	58		18	56		22	I	41		24	I	36		3	I	30		30	53		
7	54		10	61		24	59		28		42		27	I	38		9	I	28		22	54		
8	54		10	58		18	62		35	I	41		24	I	37		6	I	36		57	45		
9	56		14				68		48		42		27	I	38		9	I	30		30	62		
1550	53		8	58		18	60		31		39		18	I	41		17	I	26		13	52		
1	56		14	62		27	67		46		44		33	I	40		14	I	24		4	55		
2	49		0	49		0	46		0		33		0		35				23		0	38		

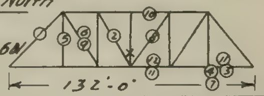
Instrument	9				10				11				12					
Location	Main Diag. Ins. Bar				Top Chord 4th Pl. Ins. Top				W. Stringer 6th Pl., E. Bot. Flge				Diagonal 4th Pl. Outs. Bot.					
													Comp.			Tens.		
No.	M	S	%E	R	M	S	%E	R	M	S	%E	P	M	S	E	M	S	E
1513	81	80	1	I	74	73	1		47	40	17		8	12		29		
4	83		4		75		3		44		10	I	14		17	25		
1515									45		12	I						
6	80		0	I+	73		0	I	47		17	I	12		0	28		
7	82		3	I	75		3	I	46		15	I	15		25	25		
8	83		4	I+	75		3	I	44		10	I	15		25	32		
9	83		4	I+	73		0	I	48		20	I	17		42	33		
1520	84	79	6	I	78	70	11		49		22	I+	14		17	30		
1	87		10	I+	81		16		47		17	I	19		58	38		
2	84		6	I+	79		13		45		12	I+	14		17	29		
3	78			I+	78		11	I	48		20	I	16		33	47		
4	77			I	75		7		42		5	I	14		17	19		
1525	82		4	I	78		11		47		17	I	13		8	24		
6	85		8	I	79		13		49		22	I	15		25	28		
7	79		0	I	68	68	0	I	44		10	I	13		8	24		
8	81	78	4	I	68		0	I	48		20	I	13		8	25		
9	81		4	I+	67				44		10	I	16		33	25		
1530	81		4		69		2	I	40		0	I	13		8	25		
1	81		4		73		7		42		5	I	14		17	25		
2	80		3		73		7		44		10	I	13		8	24		
3	92		18		79		16		44		10	I	14		17	36		
4									50		25	I+				30		
1535	79		1	I+	66	66	0	I	48		20	I	13		8	23		
6	86	80	8	I	74	72	3		40		0	I	13		8	24		
7	86		8	I	74		3		42		5	I	12		0	27		
8	88		10	I	75		4		46		15	I	15		25	23		
9	88		10		78		8		47		18	I	12		0	32		
1540	88		10	I	77		7		44		10	I	13		8	32		
1	86		8	I	75		4	I	45		12	I	12		12	32		
2	83		4		73		1		47		18	I	11			32		
3	83		4	I	72	70	3		41		3	I	14		17	28		
4	84	79	6	I+	75		7	I	44		10	I	15		25	26		
1545	85		8	I+	75		7	I	44		10	I	10			34		
6	89		13	I	81		16		44		10	I	20		67	38		
7	91		15	I+	78		11	I	45		13	I	14		17	31		
8	88		11	I+	75		7	I	41		3	I+	16		33	26		
9	85		8	I+	75		7	I	42		5	I+	18		50	58		
1550	84		6	I+	73		4	I	42		5	I+	14		17	58		
1	89		13	I	78	68	15	I	36			I+	13		8	56		
2	79		0	I	67				43		7		11			26		

TABLE 6—bi.

Savanna. Ill. Single Track, Through, Pin-Connected. Open Floor Pratt Truss. Span 132'0"
C. B. & Q.

Train:- Engine #2527 Class 4-4-2. Kind:- Simple. Cars:- 2 Loaded & Caboose.

Train Headed North
Bridge 9
Records 1553-1601
Engine 2527
Date 8-27-08



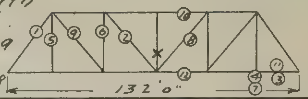
Instrument			Deflection			1				2				3				4						5				6				7				8						9				10				11				12			
Location			Cent. of Span			End Post Ins. Top				Diagonal 3rd Pl. Ins. Top				W. Stringer 6th Pl. W. Bot. Flge				Floor Beam 5th Pl. Pt. N. Bot. Flge						Hip Vert. Ins. Bar				Main Diag. Outs. Bar				Floor Beam 5th Pl. Pt. S. Bot. Flge				Diagonal 4th Pl. Ins. Top						Main Diag. Ins. Bar				Top Chd 4th Pl. Ins. Top				W. Stringer 6th Pl. E. Bot. Flge				Bot. Chd 4th Pl. Outs. Top			
																		Eng.			Car																	Comp.			Tens.																		
No.	MPH	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1553	14	9.0N	.150	.144	4	45	42	7		41	41	0		43	34	26		46	46		48	48	0	67	66	2	I					38	35	9	I	23	23	0	40			77	77	0	M					38	38	0	I	34	33	3	
4	18	9.0N	.165		15	45		7		48		17		47		38		54		12	53		10	66		0	I					38		9		25		9	40			76		1	I					40		5	I+	35		6	
1555	19	9.0N	.164		14	45		7		50		22		41		21		53		10	55		15	68		3	I					35		0	I	26		13	40			79		3	I	77	72	7	I	40		5	I+	35		6	
6	20	8.9N	.165		15	45		7		47		15	I	40		18		51		6	52		8	69		5	I					37		6	I	25		9	40			78		1	M	76		6		40		5	I+	37		12	
7	20	9.0N	.161		12	46		10		45		10	I	44		29		50		4	54		12	70		6	I					39		11	I	24		4	40			81		5	I	77		7						I+	36		9	
8	21	9.2N	.154		8	45	41	10		45		10	I	47		38		50		4	55		15	71		8	I					38		9	I	26		13	40			79		3	I	75		4		38		0	I+	35		6	
9	22	9.2N	.153	.143	7	47		15	I	46		12	I	44		29		52		8	56		17	70		6	I					40		14	I	24		4	40			80	76	5	I	73		1		40		3	I	35		6	
1560	24	9.4N	.162		13	47		15	I	48		17		43		26		53		10	56		17	69		5	I					41		17	I	24		4	40			85		12	I	73		1		43		13	I	35	32	3	
1	24	9.8N	.161		13	45		10	I	44		7		48		41		50		4	51		6	71		8	I					39		11	I	24		4	39			80		5	I+	72	70	3		39		3	I	35		9	
2	28	10.0N	.154	.142	8	45		10		50		22		46		35		52		8	49		2	72		9	I					42		20	I	24		4	40			78		3	I	70		0	I				I+	34		6	I
3	31	9.2S	.146		3	46	40	15	I	48		17	I	65		91		53		10	50		4	75		14	I					38		9	I							79		4	I+	70		0	I				I+	34		6	I
4	36	7.6S	.152		7	45		12	I	46		12	I	60		76		50		4	52		8	79		20	I+					38		9	I							79		4	I+	73		4	I				I+	37		16	I
1565	37	3.2S	.153	.140	9	50		25	I	47		15	I	82		141		51		6	52		8	68		3	I					42		20	I							77	75	3	I	76		9	I				I+	35		9	I
6	40	1.2S	.152		9	43		8	I	45		10	I	68		100		50		4	55		15	72		9	I+					42		20	I+											73		4	I				I+	35		9	I
7	41	0.4N	.148	.138	7	45		12	I	46		12	I	73		115		49		2	57		19	68		3	I+					40		14	I							79		5	I+	78	68	15	I+				I+	33		3	
8	43	2.0N	.152	.136	12	46		15	I	48		17	I	57		68		49		2	60		25	67		2	I+					38		9	I+							77		3	I	69		1	I+				I+	31	31		I
9	45	2.8N	.157	.134	17	45	39	15	I	47		15	I+	59		74		56		17	58		21	69		5	I+					38		9	I							77		3	I+	73		7	I				I+	37		19	I
																																																		E. Stgr. 6th Pl. W. Bottom							
1570	47	3.0N	.155	.133	17	45		15	I	49		20	I+	57		68		56		17	59		23	80		21	I+					40		14	I+							79		5	I+	77		13	I+				I+	42		36	I
1	49	1.8N	.155	.132	17	43		10	I	51		24	I+	85		150		54		12	58		21				I+					40		14	I										I+	73	66	11	I+				I+	37		26	I
2	50	0.4N	.160		21	45		15	I	53		29	I+	92		170		51		6	60		25				I+					40		14	I+										I+	72		9	I+				I+	38		23	I
3	52	1.5S	.157	.131	20	47		20	I	47		15	I	80		135		54		12	60		25				I+					45		29	I+										I+	72		9	I+				I+	38		23	I
																								W. Str. 5th Pl. W. Bot. Flge.																																
1574	54	2.4S	.158		21	44	38	16	I	48		17	I+	100		194		55		15	54		12				I+					45		29	I+										I+	70	64	9	I				I+	35	30	17	I
																																																		E. Stgr. 6th Pl. E. Bottom							
1575	55	8.5S	.45	.130	12	44		16	I					90		165		63		31	58		21				I+					53		52	I											74		16	I+				I+	35		17	I
6	52	7.7N	.147	.128	15	44		16	I					67		97		55		15	54		12				I+					38		9	I											69		8	I+				I+	34		13	I
7	49	3.6N	.145		13	40		5	I					62		82		54		12	59		23				I+					42		20	I											70		9	I				I+	36		20	
8	12.5	6.7N	.139	.127	9	38		0.						34		0		55		15	45					I+					35		0												62	62	0					I	29	29	0	
																								E. Stringer 4th Pl. E. Bottom																									W. Stgr. 6th Pl. W. Bottom							
9	10	3.0S	.130	.126	3	35	35	0		41	41	0													44	44	0	I					38		9								70	70	0	M	65	63	3						I+	29		4	
1580	19	3.4S	.136		8	37		6		42		2	I	46		35		48	48	0				49		11	I					37		6	I							70		0	I	65		3						I+	28	28	0	
1	30	5.2S	.133		6	36		3	I	43		10	I	76		123		52		8				51		16	I+					41		17	I							72		3	I+	62									I+	31		11	
2	34	8.4S	.146		16	38		9	I	44		7	I	56		65		56		17				50		14	I+					43		23	I+							77		10	I+	65		3						I+	29		4	I
3	37	8.8N	.143	.125	14	41		17		48		17	I	49		44		61		27				45		2	I+					38		9	I							75		7	I+	67		8	I				I+	30		7	I
4	40	2.8N	.145		16	43		23	I	49		20	I	57		68		56		17				57		30	I+					38		9	I										I+	72		14						I+	29		4	
1585	43	0.2N	.146		17	38		9	I	47		15	I+	73		115		51		6							I+					41		17	I										I+									I+	32		14	I
																																														Inst. moved along member											
1586	46	1.9S	.153	.124	23	37		6	I	49		20	I+	94		180		56		17							I+					43		23	I+										I+	74		17	I				I+	32	27	18	I
7	49	2.5S	.152		23	37		6	I					100		194		60		25							I+					40		14	I+							79		13	I				I+				I+	30		11	I
8	52	0.7N	.156		26	35	34	3	I					85		150		58		21							I+					46		31	I+							76		9	I+	73	62	18	I+				I+	30		11	I
9	54	3.1N	.148	.123	20	40		18	I					82		141		50		4							I+					41		17	I										I+	67		8	I+				I+	29		7	I
1590	44	2.9N	.148		20	38		12	I					58		70		52		8							I+					40		14	I							78	69	13	I+	69		11	I				I+	28		4	
1	46	2.9N	.146		19	38		12						65		91		56		17							I+					42		20	I							77		12	I+				I+				I+	30		11	I
2	47	2.9N	.140		14	41		21	I					59		74		57		19							I+					37		6	I+										I+				I+				I+	29		7	I
3	49	2.7S	.149	.122	22	39		15	I					92		170		58		21							I+					43		23	I+							73		6	I+				I+				I+	29	26	12	I
4	52	4.0N	.135		11	39		15	I					77		126		55		15							I+					43		23	I+							79		14	I+	67	61	10	I				I+	30		15	I
1595	53	5.6N	.136		11	40		18						85		150		53		10							I+					39		11	I										I+	68		12	I+				I+	31		19	I
6	34	7.2N	.143		17	38		12	I					53		56		59		23							I+					36		3	I										I+	63		3	I				I+				
7	35	7.2N	.140	.121	16	37	33	12	I					50		47		60		25							I+					41		17	I										I+	63		3	I				I+				
8	38	6.3N	.136		12	41		24	I					48		41		58		21							I+					41		17	I										I+	68		12					I+	28		8	
9	41	4.2N	.140		16	38		15	I					65		91		55		15							I+					36		3	I										I+	70		15	I				I+	30	25	20	
1600	44	5.0N	.135	.120	12	43		30	I					58		70		55		15							I+					36		3	I										I+	68	60	13	I				I+	29		16	
1	12	6.2N	.124		3	33		0						34		0		48		0				46		5						35		0								69		0	I	60		0						I+	22			

Column 6: Instrument off member vibration too large.

TABLE 6—bj.

Savanna, Ill. Single Track, Through, Pin-Connected, Open Floor Pratt Truss.
C.B.&Q.
Span 132'-0"

Train Headed North
Bridge #9
Records 1602-1629
Engine #2703



Train:- Engine #2703 Class 4-4-2 Kind:- Balanced Compound. Cars:- 2 Loaded & Caboose. Date 8-28-08

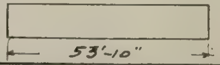
Instrument			Deflection			1				2				3				4						5				6			
Location			Cent of Span			End Post Ins Top				Diagonal 3rd Pl. Ins Top				W. Stringer 6th Pl. W. Bot.				Floor Beam N. Bot. Flge 5th Pl. Pt.						Hip Vert. Ins. Bar				2nd Pl. Post N. Inside			
																		Eng			Car										
No	MPH	C.B	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R
1602	10	8.4S	148	143	3	45	45	0		47	47	0	I	40	40	0		49	49	0	47	47	0	63	63	0					
3	44	9.2N	160		12	48		7	I	63		34		55		37		50		2	53		13	63		0	I	42	30	40	I
4	40	7.2N	161		13	47		4	I	59		26		52		30		53		8	60		28	65		3	I	36		20	I
5	44	2.2N	157	142	11	47		4	I	60		24		52		30		54		10	58		23	64		2		38		27	I
6	42	1.9S	154		8	47		4		74		58		46		15		49		0	58		23	70		11		38		27	I
7	46	1.0S	164		13	48	44	9		60	46	30		67		67		52		6	56		19	71		13		39		30	
8	49	5.0S	156	141	11	48		9	I	62		35		68		70		52		6	61		30	76		21	I	38		27	
9	52	6.2S	160		13	50		14		56		22		73		82		53		8	58		23	79		25	I	38		27	I
1610	52	9.0N	161		14	50		14	I	74		61		92		130		54		10	57		21	85		35	I	37		23	
1	55	4.6N	158	140	13	45		2	I	52		13	I	96		140		52		6	55		17	85		35	I	34		13	
2	58	2.2N	160		14	50		14	I	45			I	111		178		52		6	55		17	79		25	I	33		10	I
3	10	4.8N	140		0	45		2		46		0	I	36				49		0	46			64		2		32		7	
			Coal Cars taken off																												
1614	10	7.6N	126	123	2	36	36	0		46	46	0	I	40	40	0		49	49	0				66	63	5		30		0	
5	41	3.7N	127		3	39		8		49		7	I	44		10		52		6				65		3		36		20	
6	43	2.3N	136		11	40		11		56		22		55		37		52		6				69		10		38		[illegible]7	
7	46	0.2S	136	122	11	40		11		64		39		68		70		52		6				74		17	I	35		17	
8	49	1.6S	130		7	36		0	I	60	46	30	I	70		75		55		12				75		19	I	35		17	
9	50	4.5N	132	127	4					60		30	I															34		13	
1620	49	5.1N	135		6					57		24																38		27	
1	51	5.9N	140		10					55		20																33		10	
2	59	6.4N	133		5					56		22																29			I
3	57	8.7N	139		9					48		4	I															33		10	I
4	55	9.4N	141		11					50	45	11	I															32		7	I
1625	53	7.5N	141		11					58		29	I															33		10	
6	10	9.6N	129		2					45		0	I															31		3	
7	29	7.7N	134		6					44			I															34		13	I
8	33	4.4N	132		4					45		0	I															34		13	I
9	39	3.7N	135		6					46	44	4	I															36		20	

Instrument	7				8						9				10				11				12			
Location	Floor Beam 5th Pl. Pt. S. Bot. Flge				Diagonal 4th Pl. Ins. Top						Main Diag. Ins Bar				Top Chd 4th Pl. Ins. Top				W. Stringer 4th Pl. W. Bot. Flge				Bot. Chd 4th Pl. Outs. Top			
					Comp			Tens																		
No	M	S	%E	R	M	S	E	M	S	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1602	41	39	5		25	23	9	42			78	78	0		74	74	0		55	50	10		32	32	0	
3	39		0	I	25		9			M I	78		0	I+	79		7		55		10	I+	36		13	I
4	39		0	I	25		9	42		M I	88		13	I+	77		4		56		12	I	35		9	
5	40		3	I	24		4			I+	80		3	I+					58		16	I	35		9	I
6	41		5	I	25		9	42		M I	77			I	76		3	I	57		14	I+	34		6	I
7	40		3	I	25		9	42		M I	82	76	8	I+	78		5		53		6	I	39	31	26	I
8	40		3	I	25		9			I+	83		9	I+	76	72	6	I	52		4	I+	38		23	
9	43		10	I	23		0			I	79		4	I+	77		7	I	52		4	I+	36		16	I
1610	45		15	I	24		4				82		8	I	77		7	I	51		2	I	40		29	I
1	52		33	I	24		4				85		12	I	80		11	I	40			I+	43		39	I
2	40		3	I	26		13				82		8	I	76		6	I	35			I	40	30	33	I
3	38				23		0	38			77		1		66	70			49				30		0	
1614	39		0		23		0	45			70	70	0		62	62	0		53	50	6		30	29	3	I
5	44		13		23		0	49			72		3	I+	63		2		70		20	I	30		3	I
6	44		13	I	23		0				72		3	I	62		0	I	56		12	I	29		0	
7	45		15	I	23		0				73		4	I	64		3	I	57		14	I	31		7	
8	44		13	I	23		0				74		6	I	66		6	I	58		16	I	33	30	33	I
9					24		4																			
1620					22																					
1					23		0																			
2					25		9																			
3					29		26																			
4					25		9																			
1625					24		4																			
6					23		0																			
7					27		17																			
8					25		9																			
9					24		4																			

TABLE 6—bk.

Schenectady, N.Y. Open Floor, Deck Plate Girder. Span 53'-10"
N.Y.C. & H.R. R.R.

Train Headed
Bridge # 44
Records 1700-1709
1739-1749
Engine # 3235 Elec.
8- 27-29-09



Train:- Electric Locomotive # 3235

Instrument			Deflection			9				10				11				12			
Location			Center of N. Girder			Bot. Ins. N. Girder				Bot. Out. N. Girder				Bot. Out. So. Girder				Bot. Ins. So. Girder			
No	M.P.H.	L.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1700	W29		58	57	2	50	48	4		39	37	5		41	39	5					
1	E70		61		7	52		8		39		5		41		5		26	25	4	
2	W61		59		4	53		10		41		11		40		3		27		8	
3	E63		60		5	52		8		40		8		40		3		26		4	
4	W60		62		9	55		15		43		16		42		8		27		8	
1705	E15		57		0	50		4		37		0		39		0		25		0	
6	W60		61		7	53		10		42		14		45		15		27		8	
7	E61		61		7	48		0		43		16		51		31		27		8	
8	W45		61		7	50		4		46		24		50		28		24			
9	E63		59		4	46				42		14		51		31		30		20	
1739	W14		57		0	48		0		36	36	0		39	39	0					
1740	E15		58		2	48		0		36		0		40		3		24	23	4	
1	E44		59		4	51		6		40		11		44		13		26		13	
2	W50		62		9	53		10		39		8		43		10		25		9	
3	E53		62		9	53		10		39		8		45		15		26		13	
4	W17		57		0	49		2		36		0		41		5		24		4	
1745	E17		59		4	49		2		36		0		42		8		24		4	
6	W31		59		4	52		8		37		3		43		10		24		4	
7	E34		58		2	49		2		37		3		43		10		25		9	
8	W40		63		11	55		15		40		11		43		10		25		9	
9	E40		62		9	52		8		39		8		44		13		27		17	

Train:- Electric Locomotive # 18

Records 1710-1714
8- 28-09

1710	E66		52	43	21	40	31	29		33	28	18		35	33	6					
1	E20		43		0	31		0		28		0		33		0		16	16	0	
2	E63		53		23	41		32		34		21		35		6		18		13	
3	E72		47		9	36		16		33		18		37		12		20		25	
4	E66		52		21	40		29		35		25		35		6		17		6	

TABLE 6—bl.

Schenectady, N.Y. Open Floor, Deck Plate Girder, Span 53'-10"
N.Y.C. & H.R.R.R.

Train:- Engine #3883

Train Headed
Bridge #44
Records 1715-1738
Engine 3883
Date 10

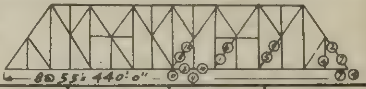
← 53'-10" →

Instrument			Deflection											9				10				11				12			
Location			Center of No. Girder											N. Girder Ins. Bot.				N. Girder Out Bot.				So. Gird. out Bot.				So. Gird. Ins. Bot.			
No.	MRH	C.B.	M.	S	%E									M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1715	20		53	53	0									45	44	2		35	33	6		36	36	0					
16	26		58		9									50		14		38		15		40		11					
17	33		57		8									50		14		36		9		38		6		18	17	6	
18	38		57		8									51		16		36		9		39		8		17		0	
19	42		59		10									51		16		37		12		38		6		18		6	
1720	50		58		9									53		20		39		18		39		8		19		12	
1	16		53		0									44		0		34		3		40		11		19		12	
2	55		55		4									45		2		35		6		39		8		19		12	
3	63		69		30									45		2		36		9		40		11		20		18	
4	67		58		9									45		2		34		3		43		19		21		24	
1725	73		56		6									46		5		39		18		44		22		22		29	
6	75		58		9									47		7		39		18		43		19		24		41	
7	80		58		9									54		23		39		18		50		39		23		35	
8	63		62		17									50		14		38		15		42		17		23		35	
9	39		57		8									54		23		40		21		39		8		20		18	
1730	20		53	52	2									46		5		34		3		36		0					
1	29													47		7		36		9		38		6		19		12	
2	18		52		0									44		0		35		6		39		8					
3	39		57		10									50		14		37		12		38		6		19		12	
4	52		58		12									48		9		37		12		41		14		23		35	
1735	54		57		13									48		9		36		9		45		25		24		41	
6	61		62		19									47		7		36		9		41		14		24		41	
7	68		66		27									47		7		38		15		45		25		26		53	
8	75		63		21									49		11		35		6		44		22		25		47	

Bellefontaine, Mo.
C B & Q RR.

Through, Pin-Connected, Open Floor, Double Track.
Baltimore Truss.
Span 440'-0"

Train Headed North →
Bridge #45
Records 1801-1835
Engine #2543



Train - Engine #2543 Class 4-4-2. Kind:- Simple Cars:- 6 Load, Coach & Private Car. 8-15-09.

Instrument			Deflection			1				2				3				4				5				6				7				8				9				10				11				12			
Location			Center of Span			Out. Bar Ins. Pair 2nd Diag.				Ins. Top End Post				Out. Bar Bot. Chd. N. Cent. Pl.				Ins. Bar 1st Sub. Vert.				Ins. Bar Out. Pair Main Diag.				Ins. Bar Out. Pair 2nd Diag.				Ins. Bot. End Post				Ins. Bot. Diag. N Cent. Pl.				Out. Bar Ins. Pair Main Diag.				Ins. Bar Bot Chd. N. Cent. Pl.				Out. Bot. E Stringer N Cent. Pl.				Ins. Top Diag. N. Cent. Pl.			
No	M.P.H.	C.B.	M	S	%E	M	S	%E	R	M	S	%E	R	M	S	%	E	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R	M	S	%E	R
1801	18					40	40	0		33	31	6		22	21	5														29	29	0			35			38	33	15		23	23	0							30		
2	26									32		3		22		5						41	40	3						30		3		36		3		38		15		23		0						33		10	
3	23									31		0		22		5						41		3										36		3		38		15		24		4						33		10	
4	27		340	334	2	42		5		32		3		23		10						42		5						31		7		37		6		36		9		24		4						32		7	
1805	23		346		4	40		0		33		6		21		0						43		8		41	41	0		31		7		35		0						23		0						33		10	
6	26		342	332	3	42		5		31		6		21		0						41		3		42		2		28	28	0		36		3		33		0										33		10	
7	25.5		360	360	0					33	32	3										44	41	7						30	29	3						39	35	11													
8	24		358	358	0	38				34		6		27	24	12						45		10		43		5		30		3		39	37	5		38		9		26	24	8		56	48	17					
9	22		362	358	1	46	44	5		33		3		26		8						42		2		42		2		31		7		39		5		38		9		26		8		56		17					
1810	21		356	356	0	46		5		33		3		24		0						43		5		43		5		30		3		38		3		37		6		25		4		47							
11	20		364		2	48		9		35		9		25		4						40	40	0		43		5		28	28	0		38		3		38		9						49		2					
12	18		366		3	46		5		33		3		23	23	0						45		12		43		5		30		7		37		0		37		6		25		4		51		6					
13	16.5		354	354	0	47		7		34		6										41		3		42		2		31		11		37		0		37		6		25		4		46							
14	20		364		3	45		2		36		12		23		0						41		3		42		2		30		7		38		3		38	34	12		24		0		56		17					
1815	19		364		3	49		11		32	31	3		24		4						42		5						28		0		37		0		39		15		24		0		50		4					
16	31		360	350	3					32		3		26		13						42		5		45		10		29				38	36	6		39		15		25		4		52		8					
17	33		362		3					33		6		25		9										43		5		30				42		17		39		15		25		4		56		17					
																		Out. Bot. N. End F.B.												Ins. Bot. N. End F.B.																							
18	37		352	348	1					32		3		26		13		13		16		43		8		43		5		50								38		12		23	23	0		56		17					
19	35±		352		1	44		0		31		0		27		17		17		12		43		8		42		2		47				40		11		33				24		4		53		10					
1820	44		350		1	47		7		33		6		24		4		16		18		42		5		42		2		42				38		6		38		12		24		4		52		8					
21	42		348	344	1	47		7		34		10		24		4		15		17		43		8		42		2						37		3		38		12						50		4					
22	40		346		1					32		3		28		22		16		17		43		8		42		2		48				38		6		35		3						48		0					
23	36		344		0	50		14		31		0		26		13		17		15		42		5		43		5		45				39		8						24		4		52		8					
24	31		370	360	3	49	43	14		35	32	9		26	24	8		17		15		42	41	2		45		10		47				40	37	8		33	33	0			24			49		2					
1825	29		362	356	2	43		0		35		9		24		0		15		17		47		15		44		7		48				40		8		33		0		26		8		50		4					
26	29		360	354	2	47		9		35		3		24		0		17		15		42		2		43		5		48				41		11		33		0		25		4		55		15					
27	26		356		1	44		2		33		3		24		0		15		17		43		5		43		5		47				38		3		33		0		24		0		52		8					
28	24			352						36		12		26		8		16		11						46		12		52								33		0		25		4		50		4					
29	21		352		0	43		0		35		9		24		0		13		15		42		2		43		5		41				40		8		35		6		25		4		48		0					
1830	20.5		354	350		47		9		34		6		23	23	0		17		13		40	40	0		43		5		43				38		3		34		3		25		4									
31	18		360		3	48		12		33		3		23		0		16		13						44		7		41				37		0		33		0		24		0									
32	19		364	348	5	50		16		33		3		23		0		13		16										43				37		0		33		0													
33	19		364		5	43		0		33		3		22				15		14										43								35		6		26		8									
34	15		346	346	0	46		7		32		0		23		0		13		14										38				39		5		34		3		24		0									
1835	16		346		0	45		5		34		6		21				16		13										45								34		3		24		0									

TABLE 7.

Table of Centrifugal force at 60 M.P.H in % of static load on Drivers.

R.R.	Engine No.	Weight of Engine only.	Diam. of Drivers	Stroke	Weight on Driver Axle	Weight of overbalance at Crankpin center		Centrifugal Force in % of Static Load on Drivers at 60 M.P.H
						Total	Per Wheel	
Ill. Cent.	1013	188000	79"	28"	51000	797	399	29
	904	203500	63"	30"	45250	919	230	31
	1018	188000	79"	28"	51000	797	399	29
	47	157200	63"	28"	40750			
	20	157200	63"	28"	40750			
	34	157200	63"	28"	40750			
C.B.&Q.	234	149700	69"	26"	38930	567	189	22
	1919	210000	69"	28"	52300	756	252	23
	1921	210000	69"	28"	52300			
	2527	187000	84¼"	26"	46500	694	347	22
	2523	187000	84¼"	26"	46500	694	347	22
	2123	216000	69"	28"	48600			
	2703	196600	78"	26"	51000	Balanced	Compound	
C.M.&St.P.	2543	187000	84¼"	26"	46500	694	347	22
	1703	178900	62"	28"	44300	1352	451	60
	304	166800	68"	26"	41330	782	261	29
	925	177500	84¼"	28"	46225	1632	816	57
	263	177000	69"	30"	45300	786	262	30
	939	177470	84¼"	28"	46225	1632	816	57
R.I.	1672	206000	63"	30"	48800	908	227	29
	819	193000	69"	26"	46000	762	254	25
	1746	198600	63"	30"	44300	856	214	30
	2200	238850	63"	32"	56150	964	241	28
Nickel Plate	147	160000	62"	28"	35500	692	173	29
	185	159000	72"	26"	39000	366	122	13
	181	123700	68"	24"	40300	486	243	26
Santa Fe	573	164000	63"	28"	44010	1233	411	54
	1403	201500	79"	26"	49600	Balanced	Compound	
	1822	248200	69"	28"	57700	Balanced	Compound	
	1824	248200	69"	28"	57700	Balanced	Compound	
	1115	210190	69"	28"	50180	1205	402	38
	542	201500	73"	26"	49600	Balanced	Compound	
	1435	204100	79"	26"	56850	Balanced	Compound	
	1066	210190	69"	28"	50180	1205	402	38
Norfolk & Western	1059	200000	56"	30"	42960	596	149	27
	1033	200000	56"	30"	42960	596	149	27
	594	196250	68"	28"	45645	267	89	10
	603	167700	79"	28"	41970	403	202	18
	494	200000	56"	30"	42960	596	149	27
Penna Lines	7204	193500	55"	28"	46000	632	158	26
	7027	176600	77"	26"	55300	537	270	17
	7451	207775	80"	26"	61625	Balanced	Compound	
N.Y.C.	3883	191000	78"	26"	54400	6.50	32.5	21

BRIDGE			Locomotive No.	Circum. of Driver c	Total Weight of Bridge & Train $W+P$	Wt. of Train to cover Bridge P	Static Deflection Inches d	Calculated Time $T=\sqrt{\frac{W+P}{P}d}$	Critical Speed		Locomotive Coefficient $\frac{Gr}{c}$	Max. Impact of Crit. Speed
Span	R.R.	Kind							Calculated	Observed		
60'-0"	Rock Island	S T Thru O.F Pl Gird	2200	16.5	494370	400870	.28	17	65		1322	
63'-0"	C.B.& Q.	3T Thru O.F Pl Gird.	2123	181					50±	50	827 ?	30
64'-0"	Santa Fe	Pony Riv. Bal Floor 2T 3 Trusses	573	16.5	507100	301500	.22	17	60		1476	
65'-5"	C.M.& St P	S.T Deck O F Pl Gird.	263	181	387300	302600	.34	20	60	65	921	48
70'-0"	"	S T Deck Con Slab Bal Flr Pl Gird.	263	18.1	624000	302600	.17	18	67	65	921	50
70'-0"	Santa Fe	S.T. Deck Bal. Floor Pl Gird.	1115	181	578000	360850	.40	.23	52	45	1316	28
77'-10½"	Penna Lines	4 T Skew Bal Box Flr.-Outs Girds-	7204	14.5	720900	264900	.245	19	50		865	
"	"	" "	7027	20.1	704500	248500	.235	.21	63		492	
"	"	" -Ins Girds-	7204	14.5	720900	264900	.125	17	57		865	
"	"	" "	7027	20.1	704500	248500	.12	.19	70		492	
80'-0"	C.M.& St.P	Deck Bal Flr Pl Gird - W. Span -	304	17.8	558600	318600	.285	.21	58	55	808	42
"	"	" "	1703	16.3	603900	363900	.28	20	55		1647	
"	"	" "	939	22.1	615770	375770	.265	20	75	60?	1460	37
"	"	" - Third Span -	939	22.1	615170	375770					1460	
92'-6"	Santa Fe	DT Thru Bal Floor Pl Gird.	573	16.5	830250	414000	.30	.22	50		1476	
100'-0"	Rock Island	S.T. Thru O F Pl. Gird.	2200	16.5	632070	430870	.53	26	42	40	1322	45
104'-0"	Penna Lines	Pony Riv. O.F.	7027	20.1	884450	380400	.235	.19	70	65	492	65
"	"	"	7204	14.5	900360	396310	.24	.19	50	48	865	48
112'-0"	Ill. Cent.	Thru Pin-Conn. Skew I Beam Flr	20	16.5	792050	389200	.30	.22	50	52		42
124'-0"	Santa Fe	Thru. Riv. Bal. Flr. D.T.	1115	181	1531300	463500	.28	.22	55	50	1316	38
"	Rock Island	Thru Riv. O.F. Truss Span	1746	16.5	651740	403300	.38	.23	47	44	1108	36
126'-0"	Norfolk & Westn	Skew. Thru Riv. O.F 2 T.	603	20.7	1066900	544900	.26	.21	65		386	
"	"	"	494	14.7	1099200	577200	.28	.21	47		862	
126'-8"	Ill Cent.	Thru Pin-Conn. O.F - Heavy Truss -	34	16.5	749600	425200	.30	.21	52	52		42
"	"	" - Light Truss -	234	181	826100	501700					577	
132'-0"	C. B. & Q	Thru. Pin-Conn, O.F	1919	181	694000	444750	.67	.29	42	43	827	29
"	"	"	1921	181	694000	444750	.66	.29	42	43	827	29
"	"	"	2527	22.1	643200	393950	.62	29	50	47	577	33
"	"	"	2523	22.1	592050	342800	.61	30	50	48	577	18
"	"	"	1919	18.1	730250	481000	.70	.30	40	40	827	30
"	"	"	2527	22.1	765600	516350	.70	.29	50	50	577	20
"	"	"	2527	22.1	592650	343400	.62	30	50	50	577	25
135'-11"	Ill. Central	"	1018	20.7	806250	537600					764	
"	"	"	47	16.5	753850	485200						
148'-6"	"	"	1013	20.7	796300	411700					714	
"	"	"	904	16.5	809200	424600					1182	
149'-0"	Santa Fe	Thru Pin-Conn. Bal Floor D.T.	1115	181	1835600	530450	.34	.26	46	45	1316	32
152'-0"	Norfolk & Westn	Thru Skew. Pin-Conn	1059	14.7	929500	645500	.88	.32	31		862	
"	"	"	594	17.8	925750	641750	.84	.32	38		297	
"	"	"	1033	14.7	929500	645500	.88	.32	31		862	
152'-6"	Rock Island	Thru Riv. O.F.	1672	16.5	763550	430760	.50	.27	42		1165	
"	"	"	819	18.1	752500	419710	.46	.26	47		774	
152'-10"	Norfolk & W.	Thru. Pin-Conn O.F.	1059	14.7	929500	645500	.88	.32	31		862	
"	"	"	603	20.7	897200	613200	.85	.32	44		386	
156'-9"	Ill. Central	"	1018	20.7	853500	553600					764	
"	"	"	47	16.5	801100	503200						
159'-9"	C.M.& St.P.	Skew. Thru. Riv. O.F	263	18.1	1005500	577600	.45	.26	46	50	921	18
"	"	"	939	22.1	1005500	578070	.40	.24	60	60	1460	23
176'-6"	"	Skew. Thru. Pin-Conn. O.F	1703	16.3	979000	614000	.81	.34±	32±	30	1647	20
"	"	"	304	17.8	941600	576600	.75	.34±	35±	40-50	808	23
"	"	"	925	22.1	970000	605000	.72	.34±	43	44	1460	34
206'-0"	Penna Lines	Thru. Riv. Crv'd Top Ch'd O.F. 2T.	7204	14.5	2171500	875610	.35	.21	46		865	
"	"	"	7204	14.5	2085400	789510	.34	.23	43		865	
"	"	"	7027	20.1	2069500	773600	.34	.23	58	60	492	22
210'-0"	Santa Fe	Thru. Pin-Conn Crv'd Top Ch'd O.F.	1066	18.1	1261580	694000	.79	.35	34	35	1316	24
228'-0"	Nickel Plate	"	147	16.3	1229600	711700	.94	.37	29	28	841	8
"	"	"	185	18.9	1249600	731700	.97	.37	34	33	357	13
"	"	"	181	17.8	1184300	666400	.87	.36	33	32	464	7
300'-0"	Santa Fe	"	1066	18.1	1986440	874000	.97	.43	28	25	1316	22
440'-0"	C.B.& Q.	Thru Pin Conn Baltimore O.F	2543	22.1	4489700	1373700	1.75	.69	21	20	577	5

TABLE 9—a.

Comparison of the Impact on the Various Truss Members in groups.

Bridge Nº	Span	Averages of Main Membrs. & 1st Diag. ①	Averages of other Web Members ②	Excess or Deficiency of 2 over 1		% of Excess or Deficiency of 2 as compared with 1.	
1	148'-6"	34.5	24		-10.5		
1	148'-6"	26.5	45	+18.5			
2	156'-9"	28.5	18		-10.5		
3	135'-11"	40	31		-9.0		
4	135'-11"	16	23	+7.0			
9	132'-0"	38.3	44	+5.7			
9	132'-0"	27	53	+26.0			
12	176'-6"	41	29		-12.0		
14	152'-6"	27.5	35	+7.5			
17	159'-9"	33	42	+9.0			
21	64'-0"	49.3	37		-12.3		
21	64'-0"	53	65	+12.0			
23	124'-0"	47	36		-11.0		
23	124'-0"	50	50				
24	149'-0"	10	31.3	+21 3			
24	149'-0"	19 5	24.3	+4.8			
24	149'-0"	43.5	56	+12.5			
26	300'-0"	28	32.8	+4.8			
26	300'-0"	21	22 4	+1.4			
27	210'-0"	19.3	17.5		-1 8		
27	210'-0"	30	28		-2.0		
28	124'-0"	41.5	40 5		-1.0		
32	152'-0"	17.8	14		-3.8		
34	153'-0"	20.5	36	+15.5			
36	126'-0"	35.8	37	+1.2			
37	206'-0"	36.3	40.5	+4.2			
42	104'-0"	52	45		-7.0		
		886.8	957.3	+151.4	-80.9	+7.9%	

Selected List

Bridge Nº	Span	Averages of Main Membrs. & 1st Diag. ①	Averages of other Web Members ②	Excess or Deficiency of 2 over 1		% of Excess or Deficiency of 2 as compared with 1.	
1	148'-6"						
9	132'-0"	27	53	+26			
17	159'-9"	33	42	+9			
23	124'-0"	50	50	0			
24	149'-0"	43.5	56	+12.5			
26	300'-0"	28	32.8	+4.8			
27	210'-0"	30.3	28.3		-2.0		
28	124'-0"	41.5	39.5		-2.0		
37	206'-0"	363	40.5	+4.2			
		2896	342.1	+565	-4.0	$+\frac{52.5}{289.6}=+17.5\%$	
				40			
				+525			

TABLE 9—b.

Comparison of the Impact on the Various Truss Members In groups.

Bridge Nº	Span	Averages of Main Membrs. 1	Averages of Other Membrs. 2	Excess or Deficiency of 2 over 1.		% of Excess or Deficiency of 2 as compared with 1.	
1	148'-6"	34.5	24		-10.5		
1	148'-6"	29	34.5	+ 5.5			
2	156'-9"	57.5	38		-19.5		
2	156'-9"	25	25				
3	135'-11"	40	31		-9.0		
4	135'-11"	19	18		-1.0		
5	112'-0"	43	24		-19.0		
6	126'-8"	56	33		-23.0		
8	126'-8"	39.5	31		- 8.5		
9	132'-0"	39	40	+ 1.0			
9	132'-0"	30	44	+14.0			
12	176'-6"	38.5	37		-1.5		
14	152'-6"	27	31.5	+4.5			
16	228'-0"	31	33	+2.0			
17	159'-9"	34	39	+5.0			
21	64'-0"	50.6	41		- 9.6		
21	64'-0"	51	61	+ 10.0			
23	124'-0"	52.3	34		-18.3		
23	124'-0"	50	50				
24	149'-0"	10	24	+14.0			
24	149'-0"	19	23.3	+ 4.3			
24	149'-0"	50	51	+ 1.0			
26	300'-0"	31.5	30.4		-1.1		
26	300'-0"	28	21.4		-6.6		
27	210'-0"	20	17.6		-2.4		
27	210'-0"	30.3	28.3		-2.0		
28	124'-0"	42.6	39.6		-3.0		
32	152'-0"	17.5	17.5				
34	152'-10"	21.6	26.5	+4.9			
36	126'-0"	33.6	39.5	+5.9			
37	206'-0"	36.3	40.5	+4.2			
42	104'-0"	57.6	49		- 8.6		
		1144.9	1077.6	+76.3	-143.6		$\frac{-67.3}{1144.9}$ = -5.9%
					+ 76.3		
					- 67.3		

TABLE 9—C.

Comparison of the Impact on the Various Truss Members in groups Selected List.

Bridge No	Span	Averages of Main Members 1	Averages of Other Members 2	Excess or Deficiency of 2 over 1.		% Excess or Deficiency of 2 as compared to 1.	
9	132'-0"	39	40	+1.0			
9	132'-0"	30	44	+14.0			
12	176'-6"	38.5	37		-1.5		-
14	152'-6"	27	31.5	+4.5			
17	159'-9"	34	39	+5.0			
21	64'-0"	50.6	41		-9.6		
21	64'-0"	51.0	61	+10.0			
23	124'-0"	52.3	34		-18.3		
23	124'-0"	50.0	50				
24	149'-0"	10.0	24	+14.0			
24	149'-0"	19	23.3	+4.3			
24	149'-0"	50	51	+1.0			
26	300'-0"	31.5	30.4		-1.1		
26	300'-0"	28	21.4		-6.6		
27	210'-0"	20	17.6		-2.4		
27	210'-0"	30.3	28.3		-2.0		
28	124'-0"	42.6	39.6		-3.0		
32	152'-0"	17.5	17.5				
34	150'-10"	21.6	26.5	+4.9			
36	126'-0"	33.6	39.5	+5.9			
37	206'-0"	36.3	40.5	+4.2			
42	104'-0"	57.6	49		-8.6		
		770.4	786.1	+68.8	-53.1	$\frac{+15.7}{770.4} = +2.04$ %	
				-53.1			
				+15.7			

TABLE 10.

Impact under Cars shown by Deflectometer

R.R.	Span	Number of Cars	Record No	Speed of Train M.P.H.	Percentage of Impact Under Cars
Nickel Plate	228'	4	585	59	33
Santa Fe	92'-6"	2	724	64	63
"	64'	2	743	64	62
"	70'	4	798	61	38
"	70'	4	842	56	32
Norfolk & Western	43'	5	1109	42	33
"	126'	3	1193	40	26
"	126'	3	1236	40	28
Penna Lines	206'	3	1288	61	36
"	78'	1	1330	52	53
"	104'	1	1430	58	37
"	104'	1	1452	63	96
"	104'	1	1487	47	59
C. B. & Q.	132'	2	1549	46	19

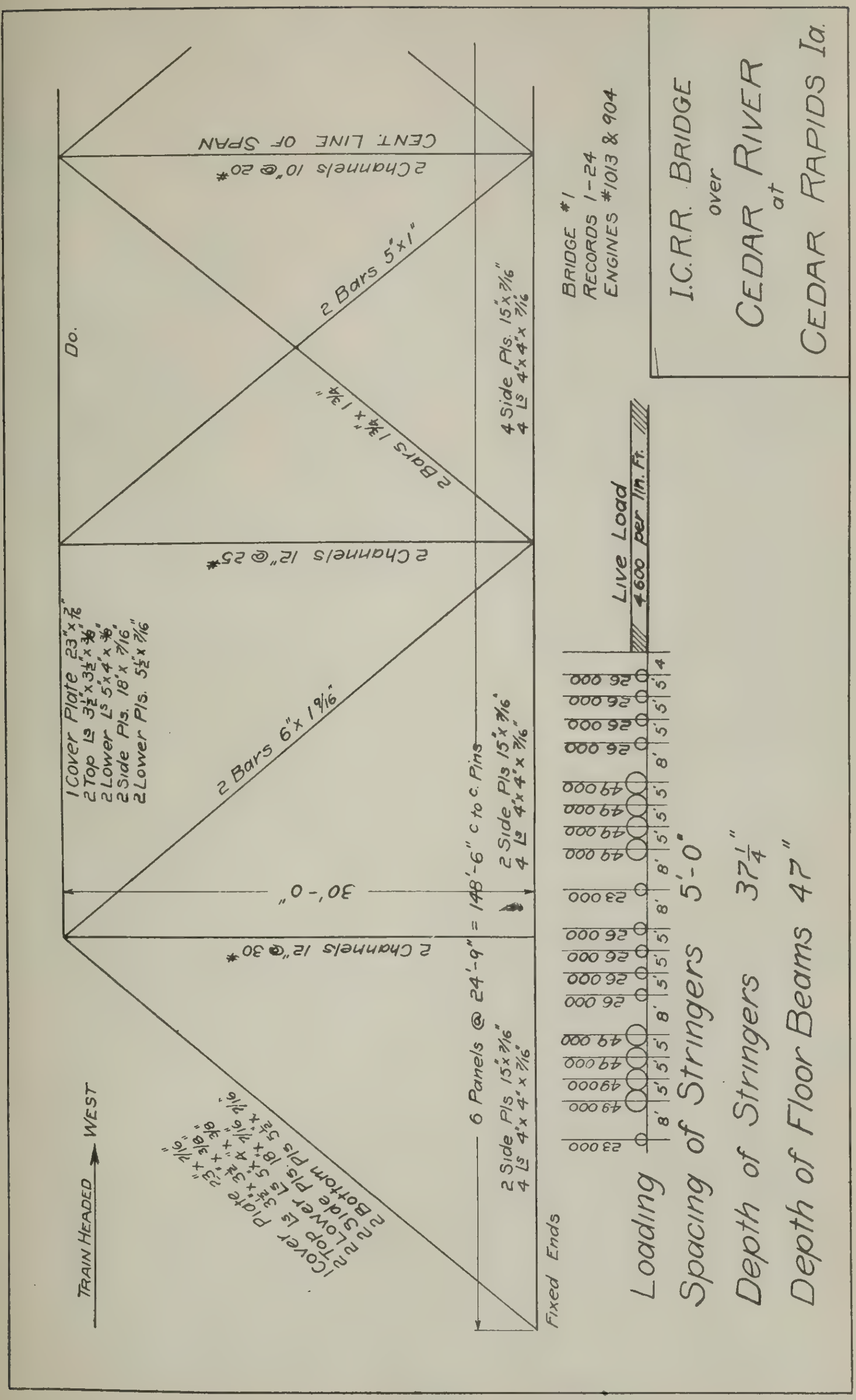
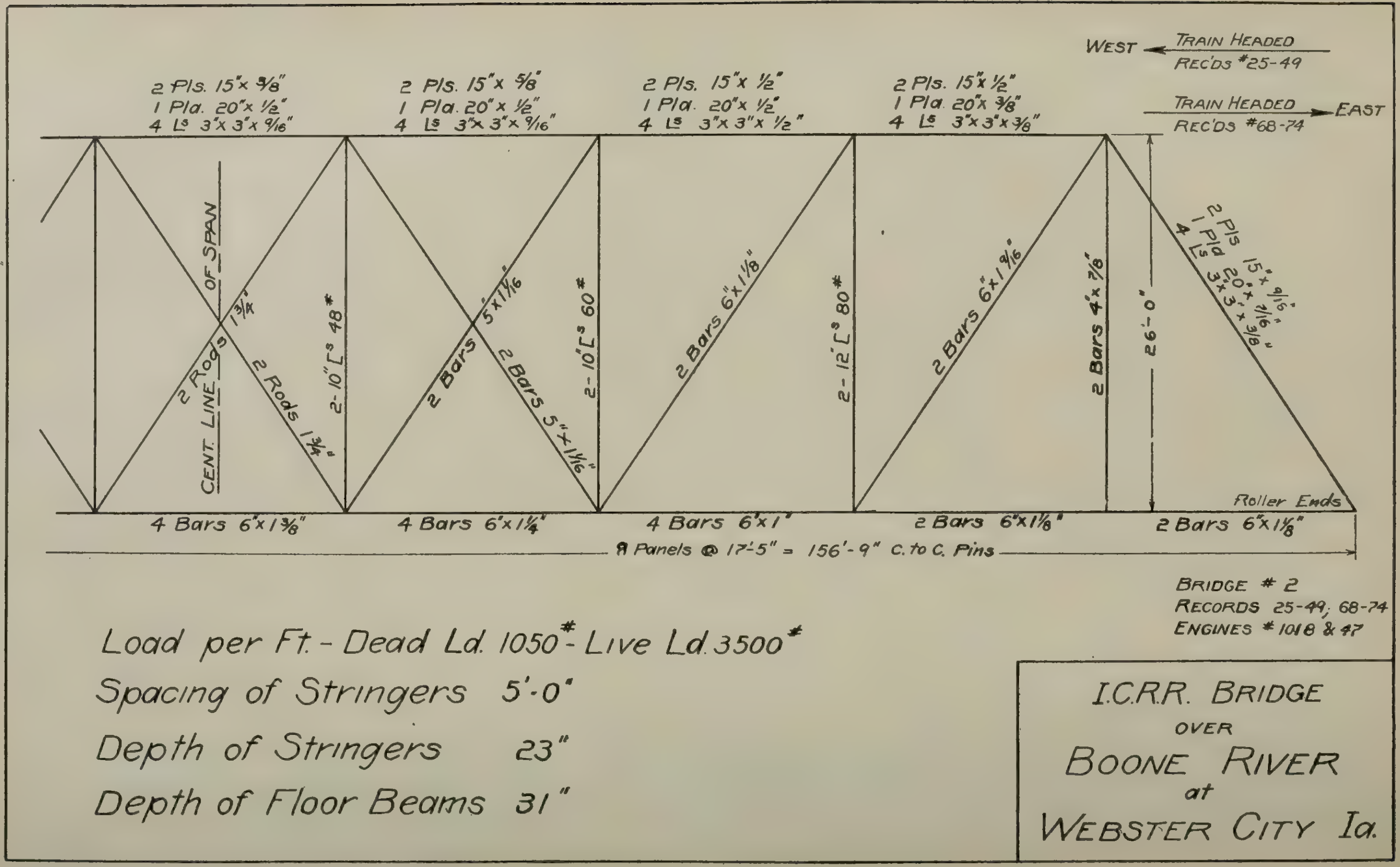
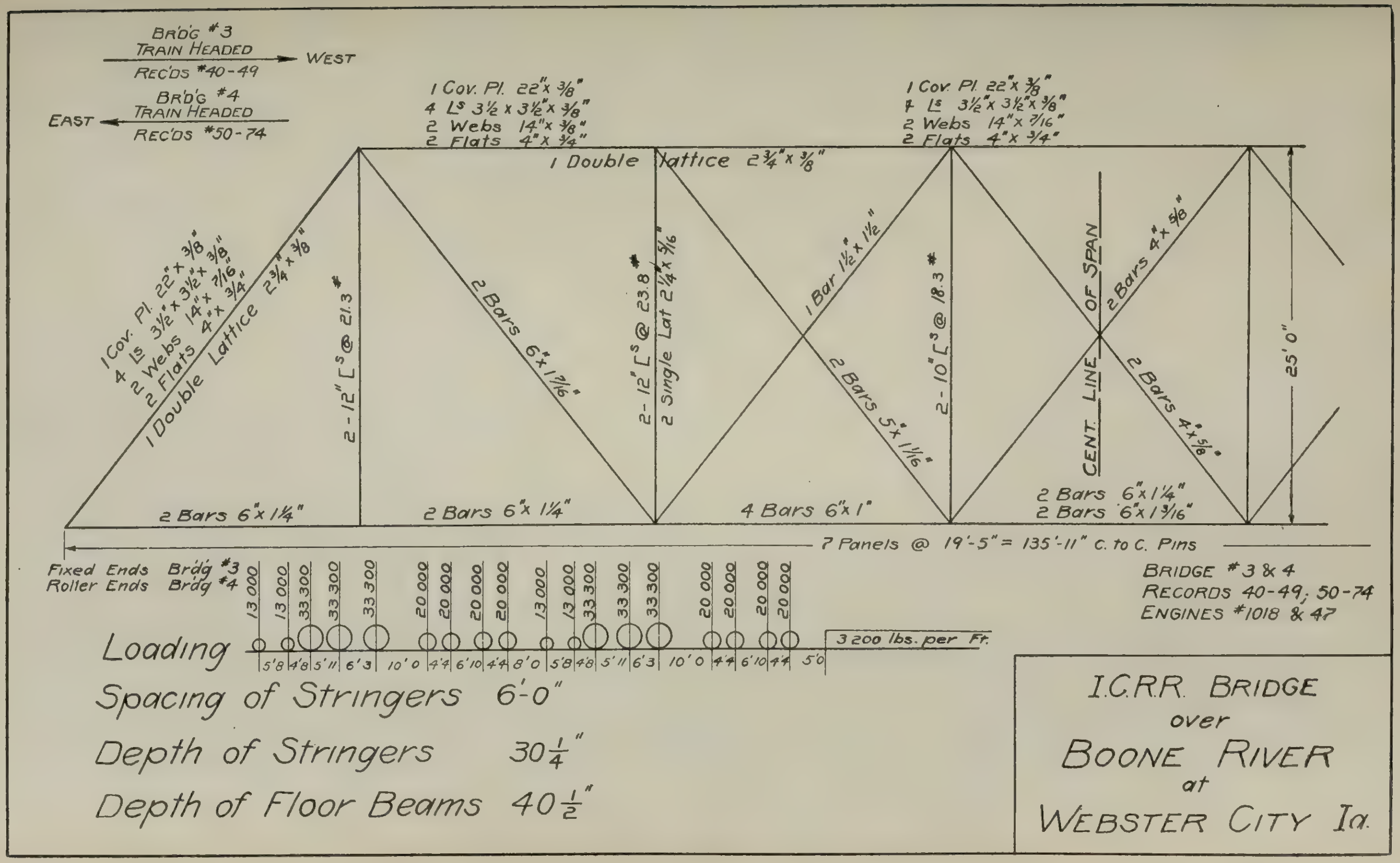
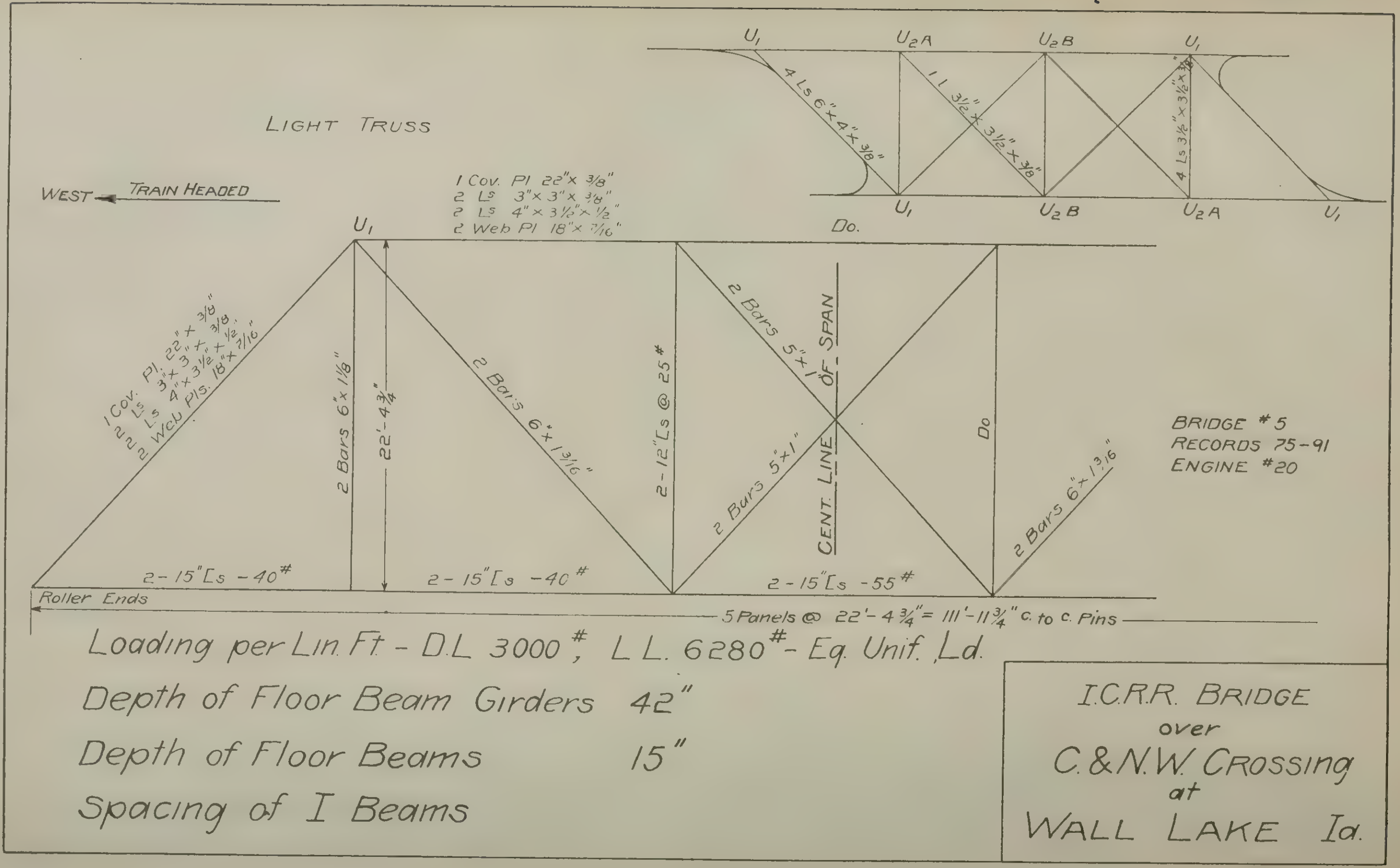
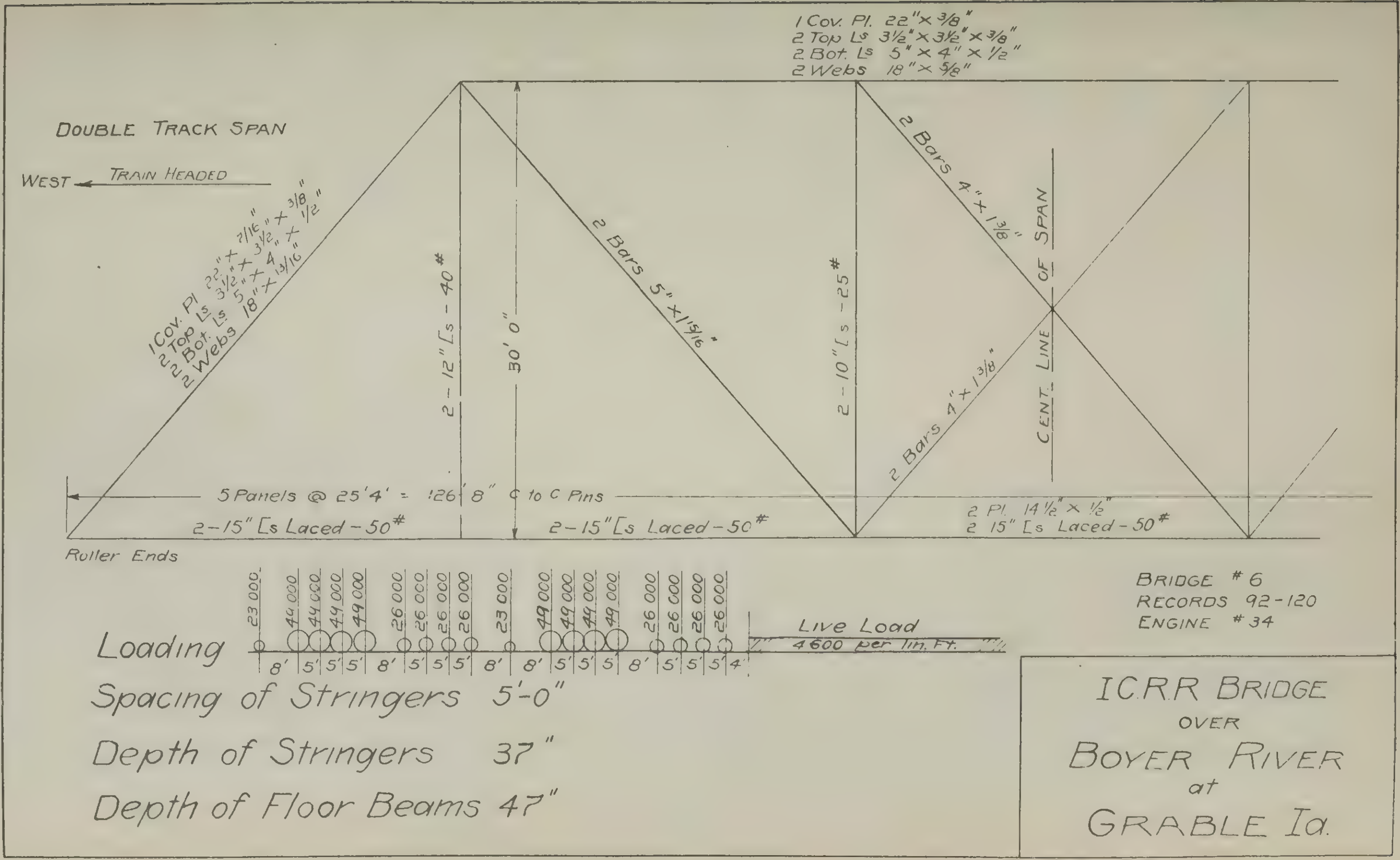

I.C.R.R. BRIDGE
over
CEDAR RIVER
at
CEDAR RAPIDS Ia.
BRIDGE #1
RECORDS 1-24
ENGINES #1013 & 904
TRAIN HEADED → WEST
Fixed Ends
CENT. LINE OF SPAN
6 Panels @ 24'-9" = 148'-6" c to c. Pins
30'-0"
2 Channels 12" @ 30#
2 Channels 12" @ 25#
2 Channels 10" @ 20#
1 Cover Plate 23"x 7/16"
2 Top Ls 3½"x3½"x⅜"
2 Lower Ls 5"x4"x⅜"
2 Side Pls 18"x 7/16"
2 Bottom Pls 5½"x 7/16"
1 Cover Plate 23"x 7/16"
2 Top Ls 3½"x3½"x⅜"
2 Lower Ls 5"x4"x⅜"
2 Side Pls. 18"x 7/16"
2 Lower Pls. 5½"x 7/16"
Do.
2 Bars 6"x 1 9/16"
2 Bars 5"x1"
2 Bars 1¾"x 1¾"
2 Side Pls 15"x 7/16"
4 Ls 4"x4"x 7/16"
2 Side Pls 15"x 7/16"
4 Ls 4"x4"x 7/16"
4 Side Pls. 15"x 7/16"
4 Ls 4"x4"x 7/16"
23 000
49 000
49 000
49 000
49 000
26 000
26 000
26 000
26 000
23 000
49 000
49 000
49 000
49 000
26 000
26 000
26 000
26 000
8' 5' 5' 5' 8' 5' 5' 5' 8' 8' 5' 5' 5' 8' 5' 5' 5' 4
Live Load
4600 per lin. Ft.
Loading
Spacing of Stringers 5'-0"
Depth of Stringers 37¼"
Depth of Floor Beams 47"

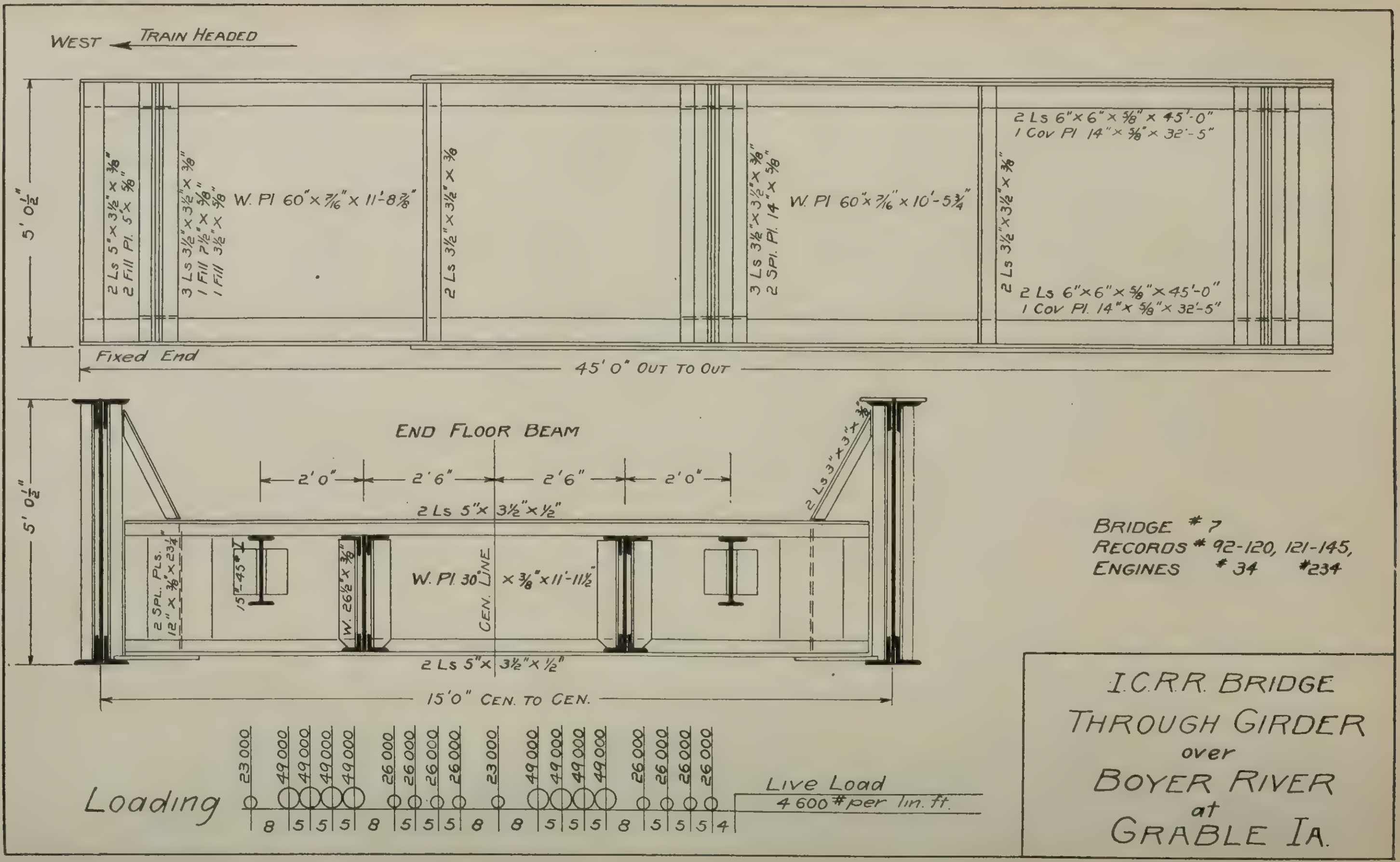
PLATE I—b.


WEST ← TRAIN HEADED
REC'DS #25-49
TRAIN HEADED → EAST
REC'DS #68-74
2 Pls. 15"× 3/8"
1 Pla. 20"× 1/2"
4 Ls 3"× 3"× 9/16"
2 Pls. 15"× 5/8"
1 Pla. 20"× 1/2"
4 Ls 3"× 3"× 9/16"
2 Pls. 15"× 1/2"
1 Pla. 20"× 1/2"
4 Ls 3"× 3"× 1/2"
2 Pls. 15"× 1/2"
1 Pla. 20"× 3/8"
4 Ls 3"× 3"× 3/8"
2 Pls 15"× 9/16"
1 Pla 20"× 7/16"
4 Ls 3"× 3"× 3/8"
CENT. LINE OF SPAN
2 Rods 1 3/4"
2 Rods 1 3/4"
2-10" [s 48#
2 Bars 5"×1 1/16"
2 Bars 5"×1 1/16"
2-10" [s 60#
2 Bars 6"×1 1/8"
2-12" [s 80#
2 Bars 6"×1 9/16"
2 Bars 4"× 7/8"
26'-0"
Roller Ends
4 Bars 6"×1 3/8"
4 Bars 6"×1 1/4"
4 Bars 6"×1"
2 Bars 6"×1 1/8"
2 Bars 6"×1 1/8"
9 Panels @ 17'-5" = 156'-9" C. to C. Pins
BRIDGE # 2
RECORDS 25-49; 68-74
ENGINES # 1018 & 47
Load per Ft. - Dead Ld. 1050# - Live Ld. 3500#
Spacing of Stringers 5'-0"
Depth of Stringers 23"
Depth of Floor Beams 31"
I.C.R.R. BRIDGE
OVER
BOONE RIVER
at
WEBSTER CITY Ia.


BR'D'G #3
TRAIN HEADED → WEST
REC'DS #40-49
BR'D'G #4
EAST ← TRAIN HEADED
REC'DS #50-74
1 Cov. Pl. 22" x 3/8"
4 Ls 3½ x 3½" x 3/8"
2 Webs 14" x 3/8"
2 Flats 4" x 3/4"
1 Double Lattice 2¾" x 3/8"
1 Cov. Pl. 22" x 3/8"
4 Ls 3½" x 3½" x 3/8"
2 Webs 14" x 7/16"
2 Flats 4" x 3/4"
1 Cov. Pl. 22" x 3/8"
4 Ls 3½ x 3½" x 3/8"
2 Webs 14" x 7/16"
2 Flats 4" x 3/4"
1 Double Lattice 2¾" x 3/8"
2 - 12" [s @ 21.3 #
2 Bars 6" x 1 7/16"
2 - 12" [s @ 23.8 #
2 Single Lat 2¼" x 5/16
1 Bar 1½" x 1½"
2 Bars 5" x 1 1/16"
2 - 10" [s @ 18.3 #
CENT. LINE OF SPAN
2 Bars 4" x 5/8"
2 Bars 4" x 5/8"
25' 0"
2 Bars 6" x 1¼"
2 Bars 6" x 1¼"
4 Bars 6" x 1"
2 Bars 6" x 1¼"
2 Bars 6" x 1 3/16"
7 Panels @ 19'-5" = 135'-11" c. to c. Pins
Fixed Ends Brdg #3
Roller Ends Brdg #4
13 000
13 000
33 300
33 300
33 300
20 000
20 000
20 000
20 000
13 000
13 000
33 300
33 300
33 300
20 000
20 000
20 000
20 000
3 200 lbs. per Ft.
5'8
4'8
5'11
6'3
10'0
4'4
6'10
4'4
8'0
5'8
4'8
5'11
6'3
10'0
4'4
6'10
4'4
5'0
Loading
Spacing of Stringers 6'-0"
Depth of Stringers 30¼"
Depth of Floor Beams 40½"
BRIDGE #3 & 4
RECORDS 40-49; 50-74
ENGINES #1018 & 47
I.C.R.R. BRIDGE
over
BOONE RIVER
at
WEBSTER CITY Ia.


LIGHT TRUSS
WEST ← TRAIN HEADED
U₁
U₂A
U₂B
U₁
4 Ls 6"x4"x 3/8"
1 L 3½" x 3½" x 3/8"
4 Ls 3½" x 3½" x 3/8"
U₁
U₂B
U₂A
U₁
Do.
1 Cov. Pl 22"x 3/8"
2 Ls 3"x 3"x 3/8"
2 Ls 4"x 3½"x ½"
2 Web Pl 18"x 7/16"
U₁
1 Cov. Pl. 22"x 3/8"
2 Ls 3"x 3"x 3/8"
2 Ls 4"x 3½"x ½"
2 Web Pls. 18"x 7/16"
2 Bars 6"x 1 1/8"
22'-4¾"
2 Bars 6"x 1 3/16"
2-12"[s @ 25#
2 Bars 5"x 1"
2 Bars 5"x 1"
CENT. LINE OF SPAN
Do
2 Bars 6"x 1 3/16"
BRIDGE #5
RECORDS 75-91
ENGINE #20
2-15"[s -40#
2-15"[s -40#
2-15"[s -55#
Roller Ends
5 Panels @ 22'-4¾" = 111'-11¾" c. to c. Pins
Loading per Lin. Ft. - D.L 3000#, L.L. 6280# - Eq. Unif. Ld.
Depth of Floor Beam Girders 42"
Depth of Floor Beams 15"
Spacing of I Beams
I.C.R.R. BRIDGE
over
C.&N.W. CROSSING
at
WALL LAKE Ia.


DOUBLE TRACK SPAN
WEST ← TRAIN HEADED
1 Cov. Pl 22" × 7/16" × 3/8"
2 Top Ls 3½" × 3½" × ½"
2 Bot. Ls 5" × 4 × 13/16"
2 Webs 18" ×
1 Cov. Pl. 22" × 3/8"
2 Top Ls 3½" × 3½" × 3/8"
2 Bot. Ls 5" × 4" × ½"
2 Webs 18" × 5/8"
2 - 12" [s - 40#
30' 0"
2 Bars 5" × 1 15/16"
2 - 10" [s - 25#
2 Bars 4" × 1 3/8"
2 Bars 4" × 1 3/8"
CENT. LINE OF SPAN
5 Panels @ 25'4' = 126' 8" ℄ to ℄ Pins
2-15" [s Laced - 50#
2-15" [s Laced - 50#
2 Pl. 14½" × ½"
2 15" [s Laced - 50#
Roller Ends
BRIDGE # 6
RECORDS 92-120
ENGINE # 34
Loading
23 000
44 000
44 000
49 000
49 000
26 000
26 000
26 000
26 000
23 000
49 000
49 000
49 000
49 000
26 000
26 000
26 000
26 000
8' 5' 5' 5' 8' 5' 5' 5' 8' 8' 5' 5' 5 8' 5' 5' 5' 4'
Live Load
4600 per lin. Ft.
Spacing of Stringers 5'-0"
Depth of Stringers 37"
Depth of Floor Beams 47"
ICRR BRIDGE
OVER
BOYER RIVER
at
GRABLE Ia.


WEST ← TRAIN HEADED
2 Ls 5"×3½"×⅜"
2 Fill Pl. 5"×⅝"
3 Ls 3½"×3½"×⅜"
1 Fill 2½"×⅝"
1 Fill 3½"×⅝"
W. Pl 60"×7/16"×11'-8⅞"
2 Ls 3½"×3½"×⅜
3 Ls 3½"×3½"×⅜"
2 Spl. Pl. 14"×⅝"
W. Pl 60"×7/16"×10'-5¾"
2 Ls 3½"×3½"×⅜"
2 Ls 6"×6"×⅝"×45'-0"
1 Cov Pl 14"×⅝"×32'-5"
2 Ls 6"×6"×⅝"×45'-0"
1 Cov Pl. 14"×⅝"×32'-5"
5' 0½"
Fixed End
45' 0" OUT TO OUT
END FLOOR BEAM
2'0"
2'6"
2'6"
2'0"
2 Ls 5"×3½"×½"
2 SPL. PLS. 12"×⅜"×23¼"
15"-45# I
W. 26½"×⅜"
W. Pl 30"×⅜"×11'-11½"
CEN. LINE
2 Ls 3"×3"×⅜"
2 Ls 5"×3½"×½"
5' 0½"
15'0" CEN. TO CEN.
BRIDGE # 7
RECORDS # 92-120, 121-145,
ENGINES # 34 #234
Loading
23000
49000
49000
49000
49000
26000
26000
26000
26000
23000
49000
49000
49000
49000
26000
26000
26000
26000
8
5
5
5
8
5
5
5
8
8
5
5
5
8
5
5
5
4
Live Load
4600 # per lin. ft.
I.C.R.R. BRIDGE
THROUGH GIRDER
over
BOYER RIVER
at
GRABLE IA.

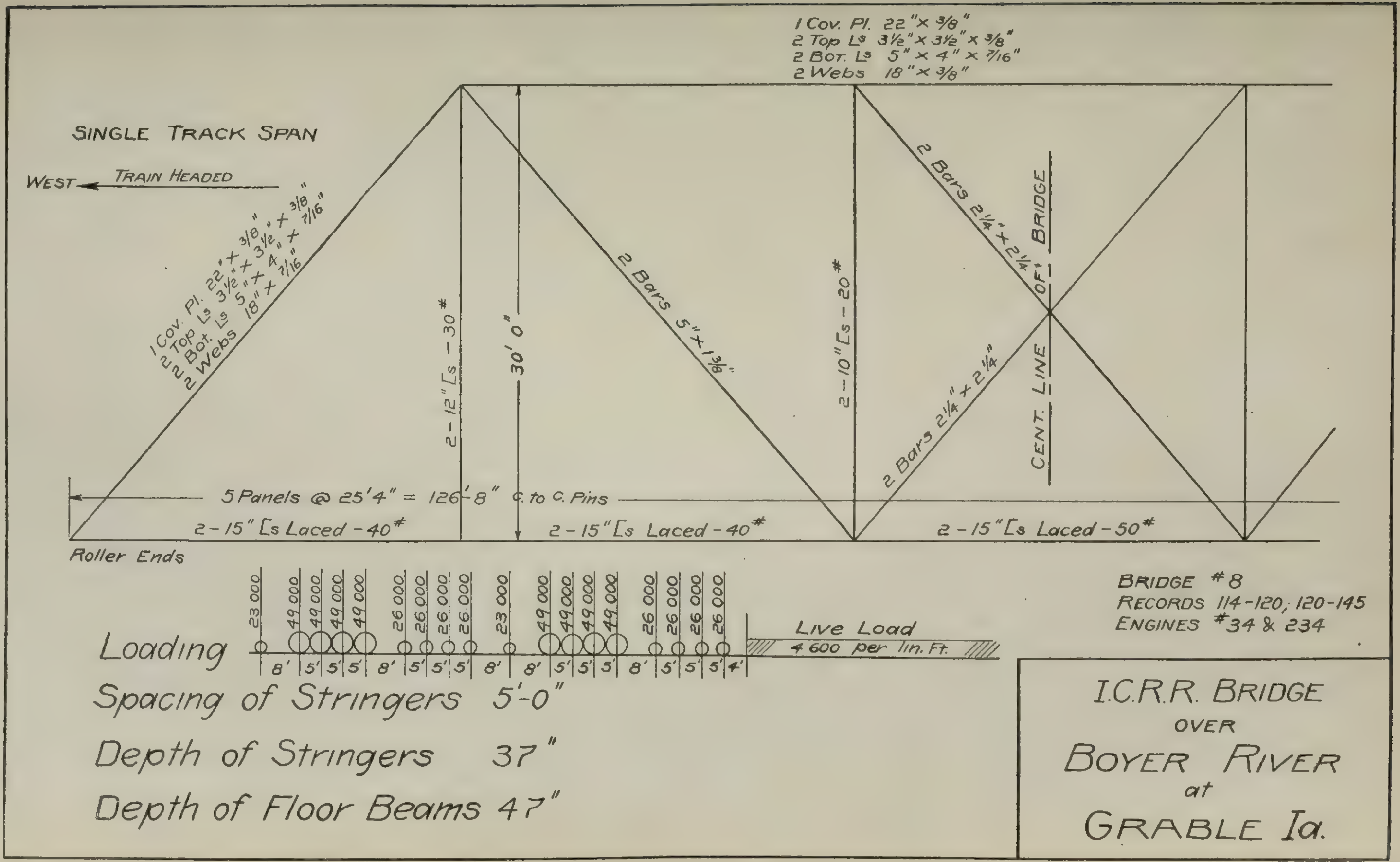
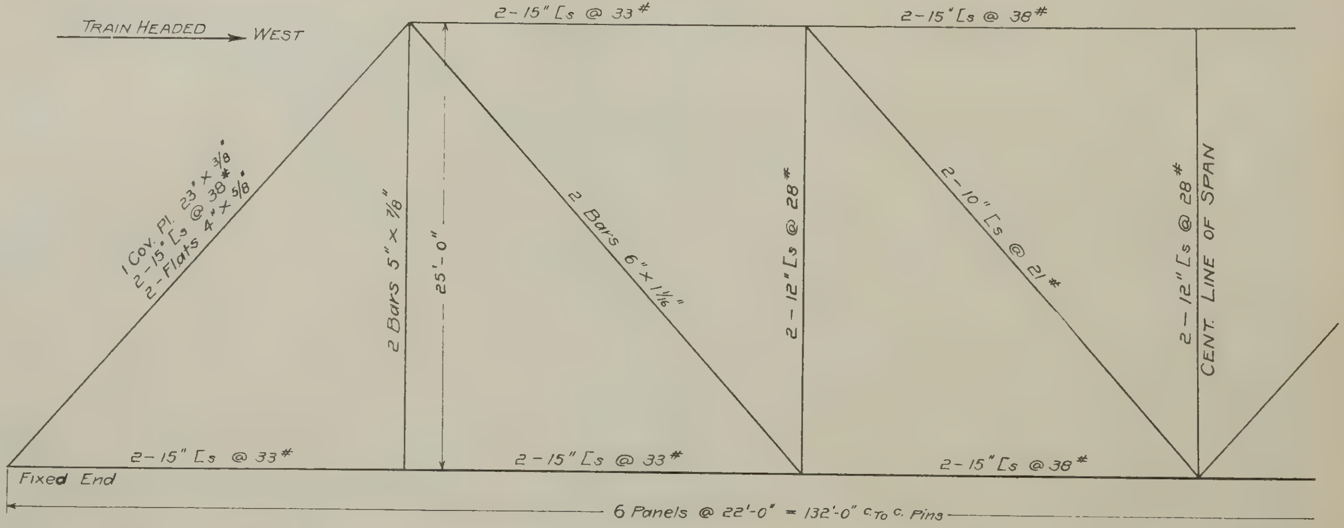

SINGLE TRACK SPAN
WEST ← TRAIN HEADED
1 Cov. Pl. 22" × 3/8"
2 Top Ls 3½" × 3½" × 3/8"
2 Bot. Ls 5" × 4" × 7/16"
2 Webs 18" × 3/8"
2 Bars 5" × 1 3/8"
2 Bars 2¼" × 2¼"
2 Bars 2¼" × 2¼"
CENT. LINE OF BRIDGE
2 - 12" [s - 30#
30' 0"
2 - 10" [s - 20#
5 Panels @ 25'4" = 126'-8" ℄ to ℄ Pins
2 - 15" [s Laced - 40#
2 - 15" [s Laced - 40#
2 - 15" [s Laced - 50#
Roller Ends
Loading
23 000
49 000
49 000
49 000
49 000
26 000
26 000
26 000
26 000
23 000
49 000
49 000
49 000
49 000
26 000
26 000
26 000
26 000
8' 5' 5' 5' 8' 5' 5' 5' 8' 8' 5' 5' 5' 8' 5' 5' 5' 4'
Live Load
4 600 per lin. Ft.
Spacing of Stringers 5'-0"
Depth of Stringers 37"
Depth of Floor Beams 47"
BRIDGE #8
RECORDS 114-120; 120-145
ENGINES #34 & 234
I.C.R.R. BRIDGE
OVER
BOYER RIVER
at
GRABLE Ia.

Plate I—h.



BRIDGE # 9

Loading - "D.L 1800# PER LIN. FT" "L.L 4000# PER LIN. FT."

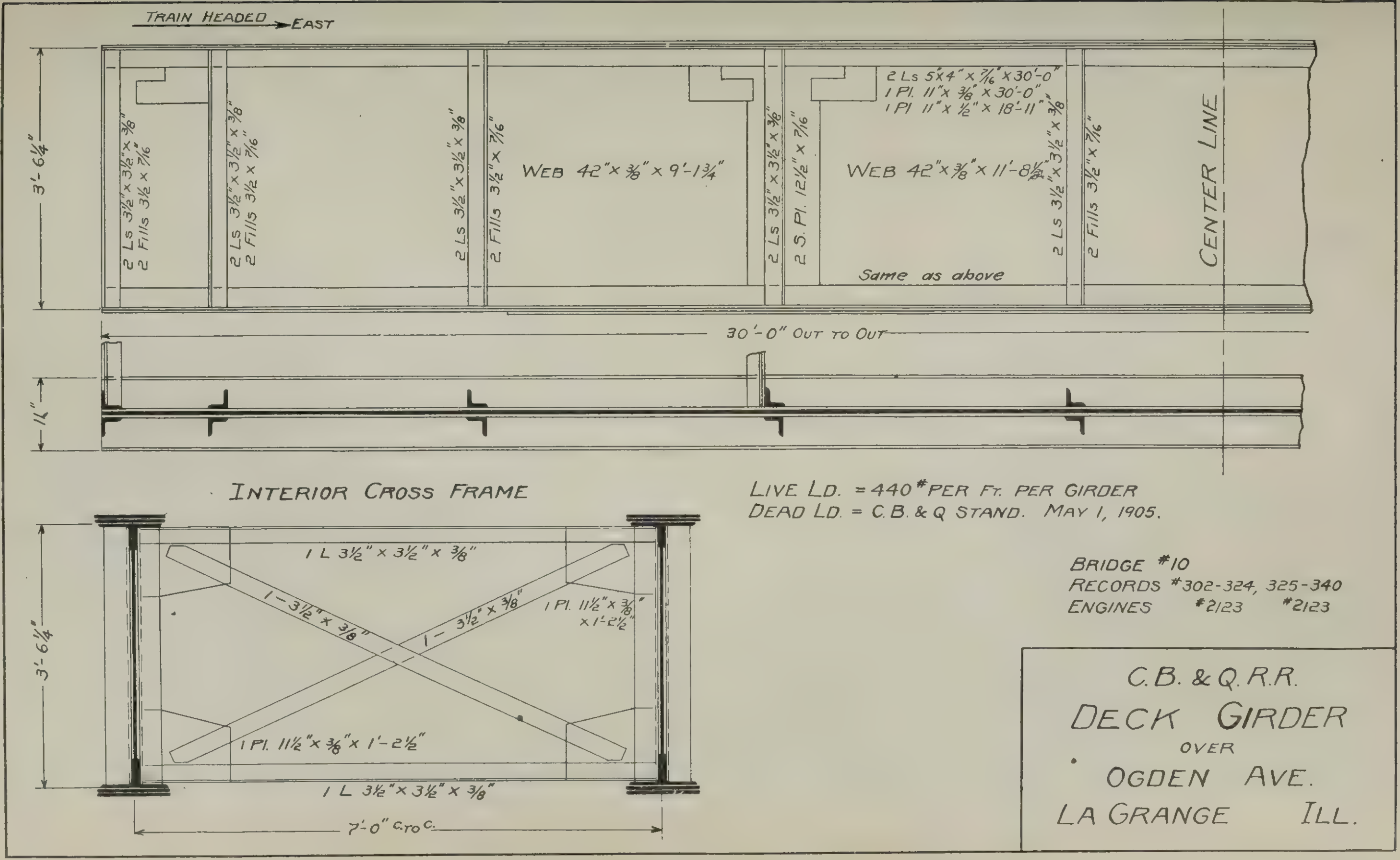
Spacing of Stringers 8'-0"

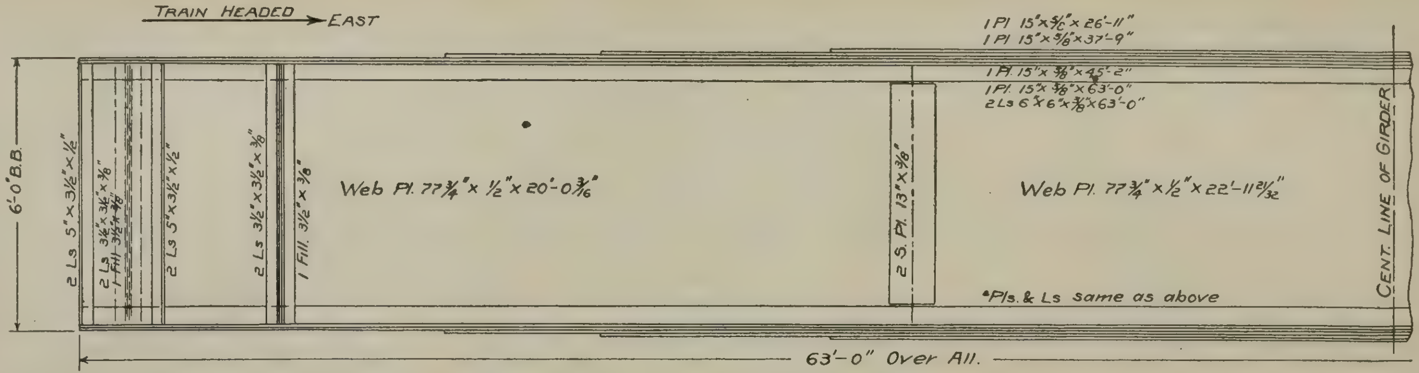
Depth of Stringers 36"

Depth of Floor Beams 48"

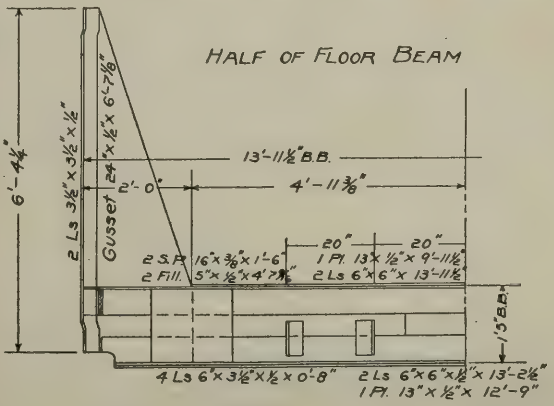
RECORDS	ENGINE
146-165	1919
166-207	1921
208-234	2527
235-264	2523
265-301	1919

C. B. & Q. R.R.
BRIDGE
over
APPLE RIVER


TRAIN HEADED → EAST
3'-6¼"
2 Ls 3½"×3½"×⅜"
2 Fills 3½×7/16
2 Ls 3½"×3½"×⅜"
2 Fills 3½×7/16"
2 Ls 3½"×3½"×⅜"
2 Fills 3½"×7/16"
WEB 42"×⅜"×9'-1¾"
2 Ls 3½"×3½"×⅜"
2 S. Pl. 12½"×7/16"
2 Ls 5"×4"×7/16"×30'-0"
1 Pl. 11"×⅜"×30'-0"
1 Pl 11"×½"×18'-11"
WEB 42"×⅜"×11'-8½"
Same as above
2 Ls 3½"×3½"×⅜"
2 Fills 3½"×7/16"
CENTER LINE
30'-0" OUT TO OUT
1'-1"
INTERIOR CROSS FRAME
1 L 3½"×3½"×⅜"
1-3½"×⅜"
1-3½"×⅜"
1 Pl. 11½"×⅜"×1'-2½"
1 Pl. 11½"×⅜"×1'-2½"
1 L 3½"×3½"×⅜"
3'-6¼"
7'-0" C. to C.
LIVE LD. = 440# PER FT. PER GIRDER
DEAD LD. = C.B. & Q STAND. MAY 1, 1905.
BRIDGE #10
RECORDS #302-324, 325-340
ENGINES #2123 #2123
C.B. & Q. R.R.
DECK GIRDER
OVER
OGDEN AVE.
LA GRANGE ILL.



HALF OF FLOOR BEAM



LOADING L.L. = C.B. & Q. STAND. MAY 1, 1905
D.L. = 0.78 T. PER LIN. FT.

NOTE—Girders tested were two center girders of a three track skew bridge with a skew of 3'-8 29/32" in 14'-0"

BRIDGE #11
RECORDS #302-324, 325-340
ENGINES #2123 #2123

C.B. & Q R.R.
THROUGH GIRDER
C.H. & W. R.R. CR'S'G.
LA GRANGE ILL.

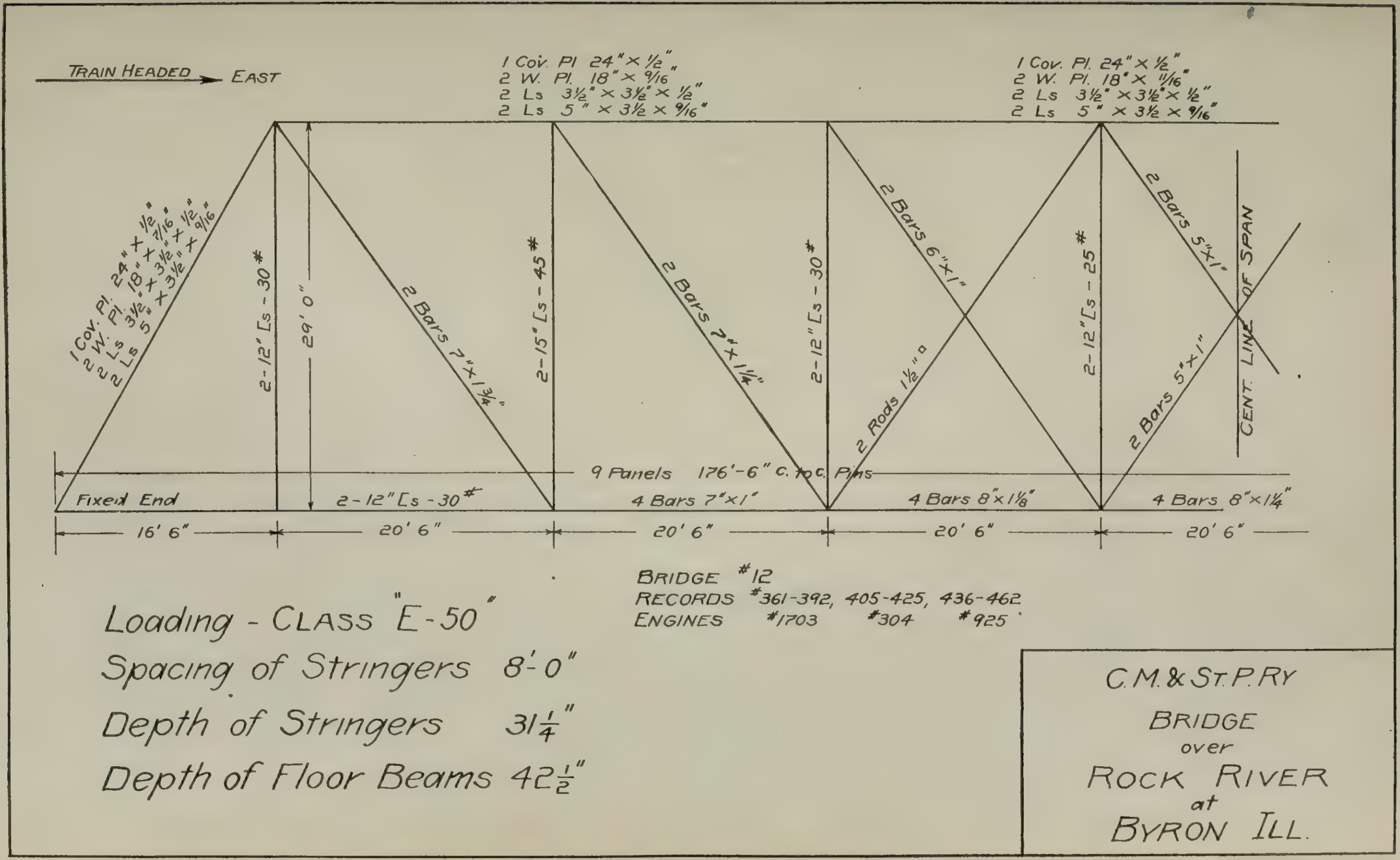
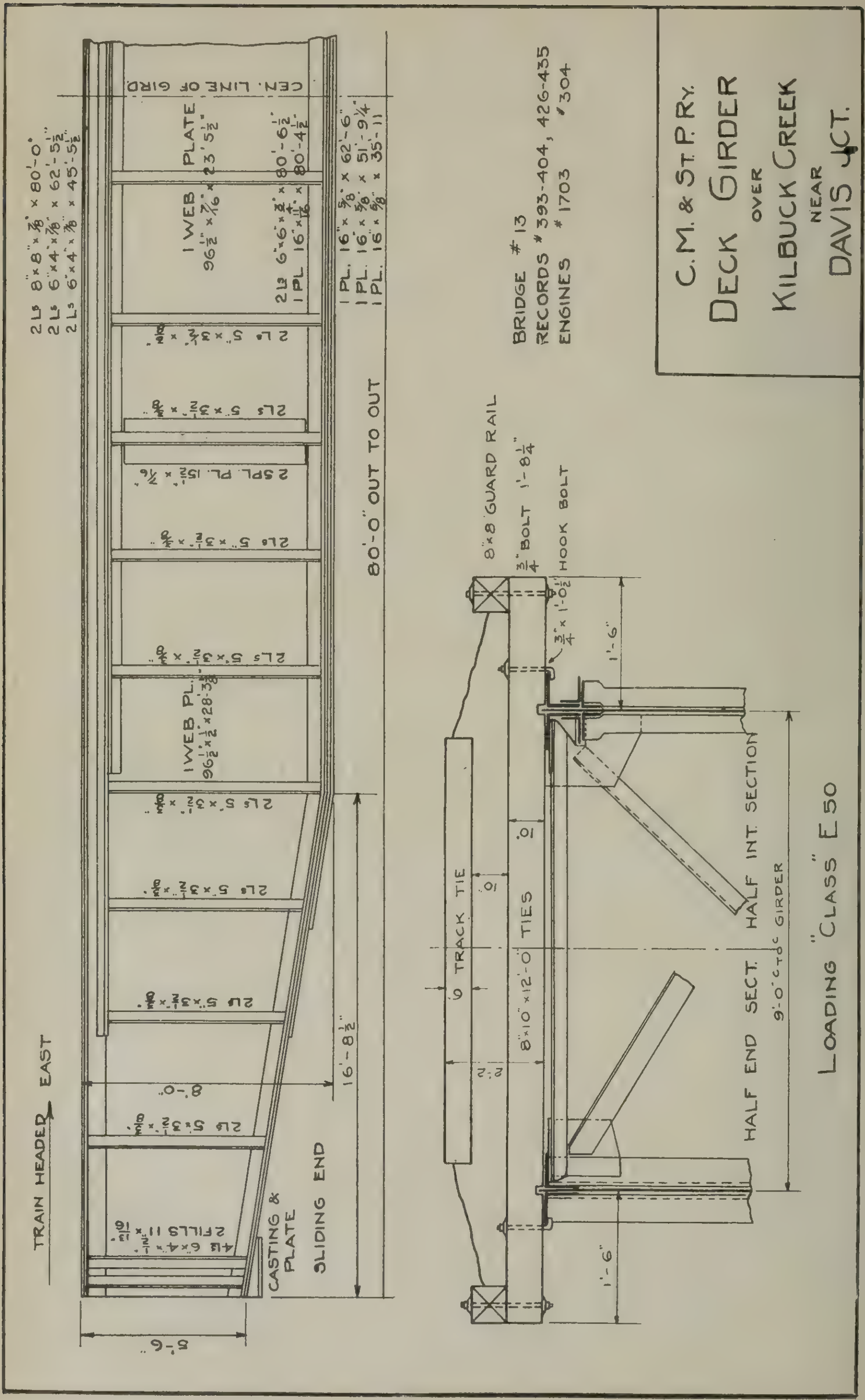

TRAIN HEADED → EAST
1 Cov. Pl. 24" × 1/2"
2 W. Pl. 18" × 7/16"
2 Ls 3 1/2" × 3 1/2" × 1/2"
2 Ls 5" × 3 1/2" × 9/16"
1 Cov. Pl 24" × 1/2"
2 W. Pl. 18" × 9/16"
2 Ls 3 1/2" × 3 1/2" × 1/2"
2 Ls 5" × 3 1/2 × 9/16"
1 Cov. Pl. 24" × 1/2"
2 W. Pl. 18" × 11/16"
2 Ls 3 1/2" × 3 1/2" × 1/2"
2 Ls 5" × 3 1/2 × 9/16"
2-12" [s - 30#
29' 0"
2 Bars 7" × 1 3/4"
2-15" [s - 45#
2 Bars 7" × 1 1/4"
2-12" [s - 30#
2 Bars 6" × 1"
2 Rods 1 1/2" □
2-12" [s - 25#
2 Bars 5" × 1"
2 Bars 5" × 1"
CENT. LINE OF SPAN
9 Panels 176'-6" C. to C. Pins
Fixed End
2-12" [s - 30#
4 Bars 7" × 1"
4 Bars 8" × 1 1/8"
4 Bars 8" × 1 1/4"
16' 6"
20' 6"
20' 6"
20' 6"
20' 6"
BRIDGE #12
RECORDS #361-392, 405-425, 436-462
ENGINES #1703 #304 #925
Loading - Class "E-50"
Spacing of Stringers 8'-0"
Depth of Stringers 31 1/4"
Depth of Floor Beams 42 1/2"
C.M. & St. P. Ry
BRIDGE
over
ROCK RIVER
at
BYRON ILL.

PLATE I—1.


C. M. & St. P. Ry.
DECK GIRDER
OVER
KILBUCK CREEK
NEAR
DAVIS JCT.
BRIDGE # 13
RECORDS # 393-404, 426-435
ENGINES # 1703 # 304
LOADING "CLASS" E 50
2 Ls 8"×8"×7/8" × 80'-0"
2 Ls 6"×4"×7/8" × 62'-5½"
2 Ls 6"×4"×7/8" × 45'-5½"
CEN. LINE OF GIRD.
1 WEB PLATE
96½"×7/16"×23'5½"
2 Ls 6"×6"×3/4"×80'-6½"
1 PL 16"×11/16"×80'-4½"
1 PL. 16"×5/8"×62'-6"
1 PL. 16"×5/8"×51'-9¼"
1 PL. 16"×5/8"×35'-11
2 Ls 5"×3½"×3/8"
2 SPL. PL. 15½"×7/16"
1 WEB PL.
96½"×½"×28'3⅜"
80'-0" OUT TO OUT
16'-8½"
8'-0"
8'-6"
2 FILLS 11"×13/16"
4 Ls 6"×4"×½"
CASTING & PLATE
SLIDING END
TRAIN HEADED EAST
8"×8" GUARD RAIL
3/4" BOLT 1'-8¼"
3/4"×1'-0½" HOOK BOLT
1'-6"
10"
6" TRACK TIE
8"×10"×12'-0" TIES
2'-2"
HALF INT. SECTION
HALF END SECT.
9'-0" c to c GIRDER
1'-6"

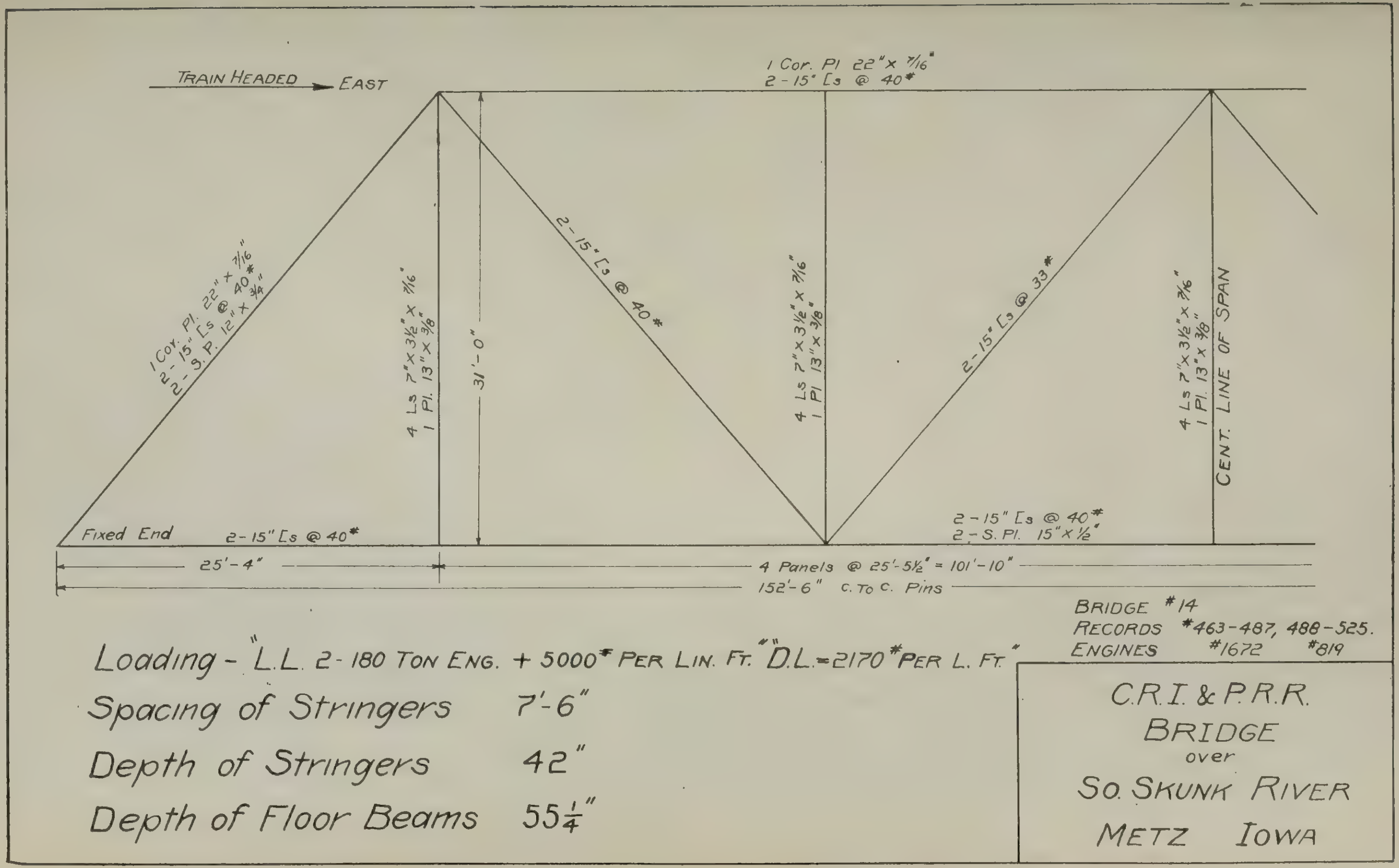
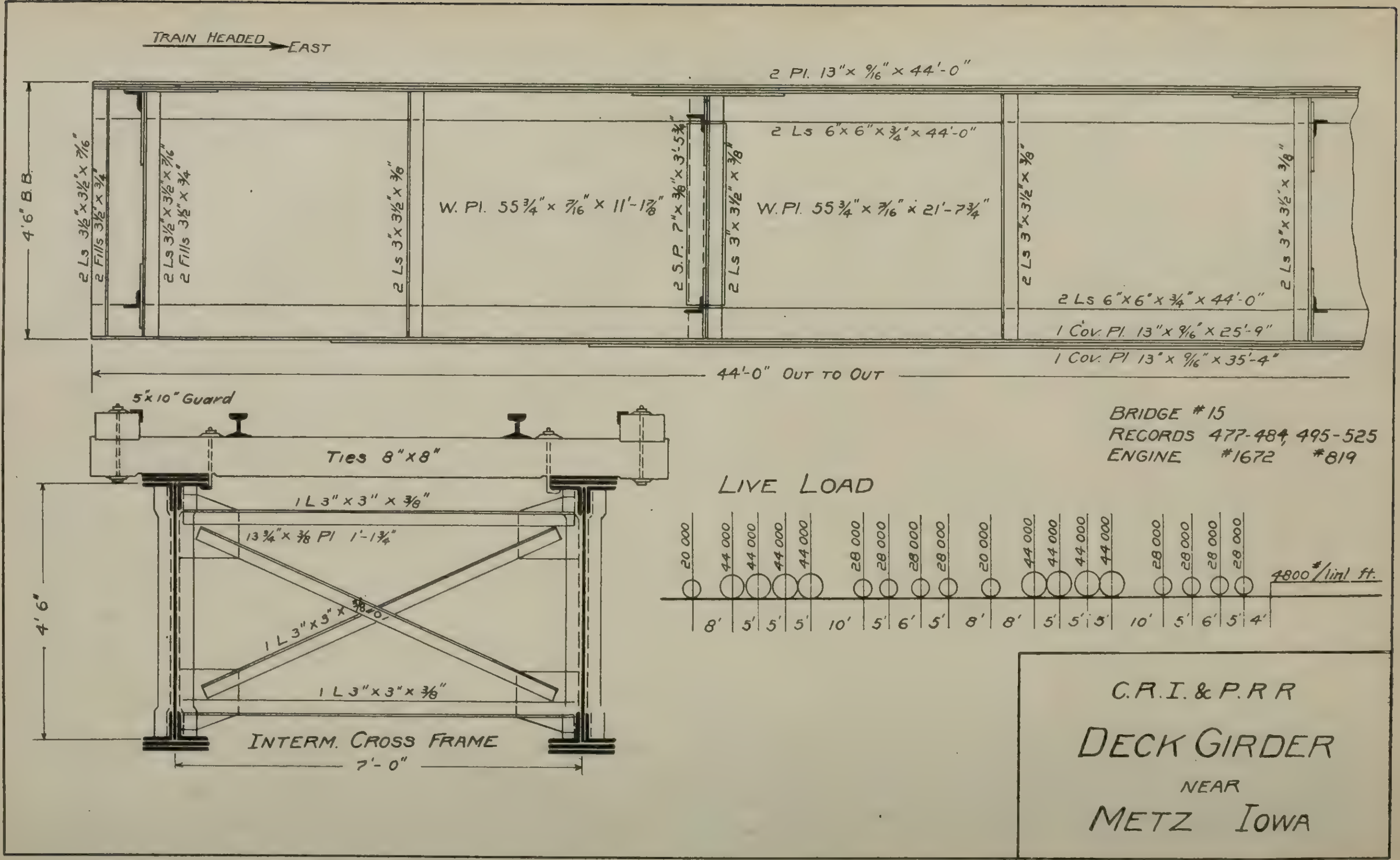
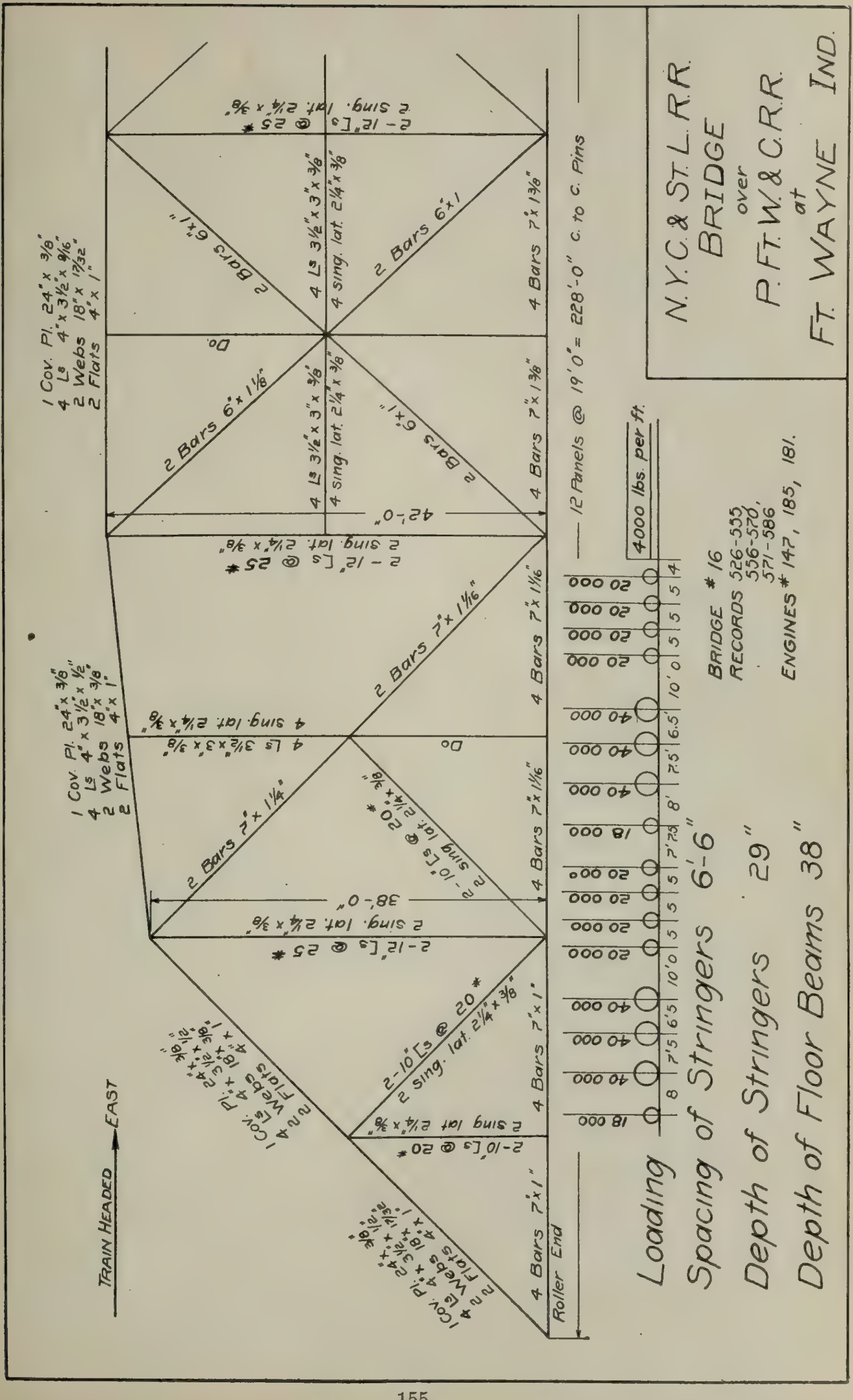
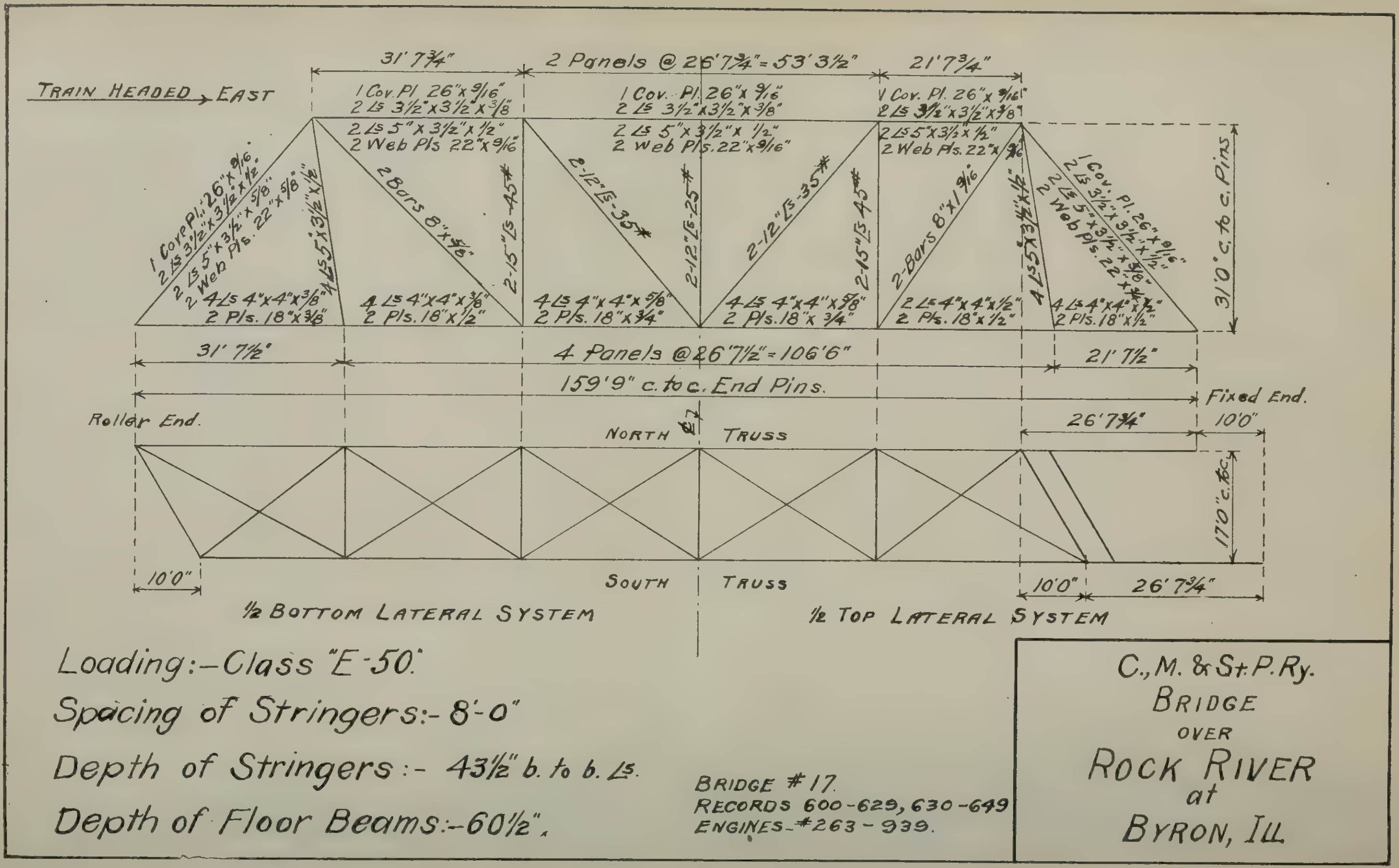

TRAIN HEADED → EAST
1 Cor. Pl 22" x 7/16"
2-15" [s @ 40#
1 Cor. Pl. 22" x 7/16"
2-15" [s @ 40#
2-S. P. 12" x 3/4"
4 Ls 7" x 3½" x 7/16"
1 Pl. 13" x 3/8"
31'-0"
2-15" [s @ 40#
4 Ls 7" x 3½" x 7/16"
1 Pl 13" x 3/8"
2-15" [s @ 33#
4 Ls 7" x 3½" x 7/16"
1 Pl. 13" x 3/8"
CENT. LINE OF SPAN
Fixed End
2-15" [s @ 40#
2-15" [s @ 40#
2-S. Pl. 15" x ½"
25'-4"
4 Panels @ 25'-5½" = 101'-10"
152'-6" C. To C. Pins
BRIDGE #14
RECORDS #463-487, 488-525.
ENGINES #1672 #819
Loading - "L.L. 2-180 TON ENG. + 5000# PER LIN. FT." "D.L.=2170# PER L. FT."
Spacing of Stringers 7'-6"
Depth of Stringers 42"
Depth of Floor Beams 55¼"
C.R.I. & P.R.R.
BRIDGE
over
SO. SKUNK RIVER
METZ IOWA

PLATE I—n.



C.R.I. & P.R.R
DECK GIRDER
NEAR
METZ IOWA


N.Y.C. & St. L. R.R.
BRIDGE
over
P. Ft. W. & C. R.R.
at
Ft. Wayne Ind.
TRAIN HEADED → EAST
Roller End
4 Bars 7"x1"
4 Bars 7"x1"
4 Bars 7"x 1 1/16"
4 Bars 7"x 1 1/16"
4 Bars 7"x 1 3/8"
4 Bars 7"x 1 3/8"
1 Cov. Pl. 24"x 3/8"
4 Ls 4"x 3½"x ½"
2 Webs 18"x 17/32"
2 Flats 4"x 1"
1 Cov. Pl. 24"x 3/8"
4 Ls 4"x 3½"x ½"
2 Webs 18"x 3/8"
2 Flats 4"x 1"
1 Cov. Pl. 24"x 3/8"
4 Ls 4"x 3½"x ½"
2 Webs 18"x 3/8"
2 Flats 4"x 1"
1 Cov. Pl. 24"x 3/8"
4 Ls 4"x 3½"x 9/16"
2 Webs 18"x 17/32"
2 Flats 4"x 1"
2-10"[s @ 20*
2 sing lat 2¼"x 3/8"
2-10"[s @ 20*
2 sing. lat. 2¼"x 3/8"
2-12"[s @ 25*
2 sing. lat. 2¼"x 3/8"
2 Bars 7"x 1¼"
2-10"[s @ 20*
2 sing lat. 2¼"x 3/8"
4 Ls 3½"x 3"x 3/8"
4 sing. lat. 2¼"x 3/8"
Do.
2 Bars 7"x 1 1/16"
2-12"[s @ 25*
2 sing. lat. 2¼"x 3/8"
2 Bars 6"x 1 1/8"
4 Ls 3½"x 3"x 3/8"
4 sing. lat. 2¼"x 3/8"
2 Bars 6"x1"
Do.
2 Bars 6"x1"
4 Ls 3½"x 3"x 3/8"
4 sing. lat. 2¼"x 3/8"
2 Bars 6"x1"
2-12"[s @ 25*
2 sing. lat. 2¼"x 3/8"
38'-0"
42'-0"
12 Panels @ 19'0" = 228'-0" c. to c. Pins
18 000
40 000
40 000
40 000
20 000
20 000
20 000
20 000
18 000
40 000
40 000
40 000
20 000
20 000
20 000
20 000
4000 lbs. per ft.
8
7'5
6'5
10'0
5
5
5
7'2.5
8'
7.5'
6.5'
10'0
5
5
5
4
Loading
Spacing of Stringers 6'-6"
Depth of Stringers 29"
Depth of Floor Beams 38"
BRIDGE # 16
RECORDS 526-535
556-570,
571-586
ENGINES * 147, 185, 181.


TRAIN HEADED → EAST
31' 7¾"
2 Panels @ 26' 7¾" = 53' 3½"
21' 7¾"
1 Cov. Pl 26" x 9/16"
2 ∠s 3½" x 3½" x 3/8"
2 ∠s 5" x 3½" x ½"
2 Web Pls 22" x 9/16"
1 Cov. Pl. 26" x 9/16"
2 ∠s 3½" x 3½" x 3/8"
2 ∠s 5" x 3½" x ½"
2 Web Pls. 22" x 9/16"
1 Cov. Pl. 26" x 9/16"
2 ∠s 3½" x 3½" x 3/8"
2 ∠s 5" x 3½ x ½"
2 Web Pls. 22" x 9/16
1 Cov. Pl.: 26" x 9/16"
2 ∠s 3½" x 3½" x ½"
2 ∠s 5" x 3½" x 5/8"
2 Web Pls. 22" x 5/8"
4 ∠s 5" x 3½" x ½"
2 Bars 8" x 5/8"
2-15" [s-45#
2-12" [s-35#
2-12" [s-25#
2-12" [s-35#
2-15" [s 45#
2-Bars 8" x 1 9/16
4 ∠s 5" x 3½" x ½"
1 Cov. Pl. 26" x 9/16"
2 ∠s 3½" x 3½" x ½"
2 ∠s 5" x 3½" x 5/8"
2 Web Pls. 22" x 5/8"
4 ∠s 4" x 4" x 3/8"
2 Pls. 18" x 3/8"
4 ∠s 4" x 4" x 3/8"
2 Pls. 18" x ½"
4 ∠s 4" x 4" x 5/8"
2 Pls. 18" x ¾"
4 ∠s 4" x 4" x 5/8"
2 Pls. 18" x ¾"
2 ∠s 4" x 4" x ½"
2 Pls. 18" x ½"
4 ∠s 4" x 4" x ½"
2 Pls. 18" x ½"
31'0" c. to c. Pins
31' 7½"
4 Panels @ 26' 7½" = 106' 6"
21' 7½"
159' 9" c. to c. End Pins.
Fixed End.
Roller End.
26' 7¾"
10'0"
NORTH
℄
TRUSS
17'0" c. to c.
10'0"
SOUTH
TRUSS
10'0"
26' 7¾"
½ BOTTOM LATERAL SYSTEM
½ TOP LATERAL SYSTEM
Loading:—Class "E-50."
Spacing of Stringers:— 8'-0"
Depth of Stringers:— 43½" b. to b. ∠s.
Depth of Floor Beams:—60½".
BRIDGE #17.
RECORDS 600-629, 630-649
ENGINES—#263-939.
C., M. & St. P. Ry.
BRIDGE
OVER
ROCK RIVER
at
BYRON, ILL.

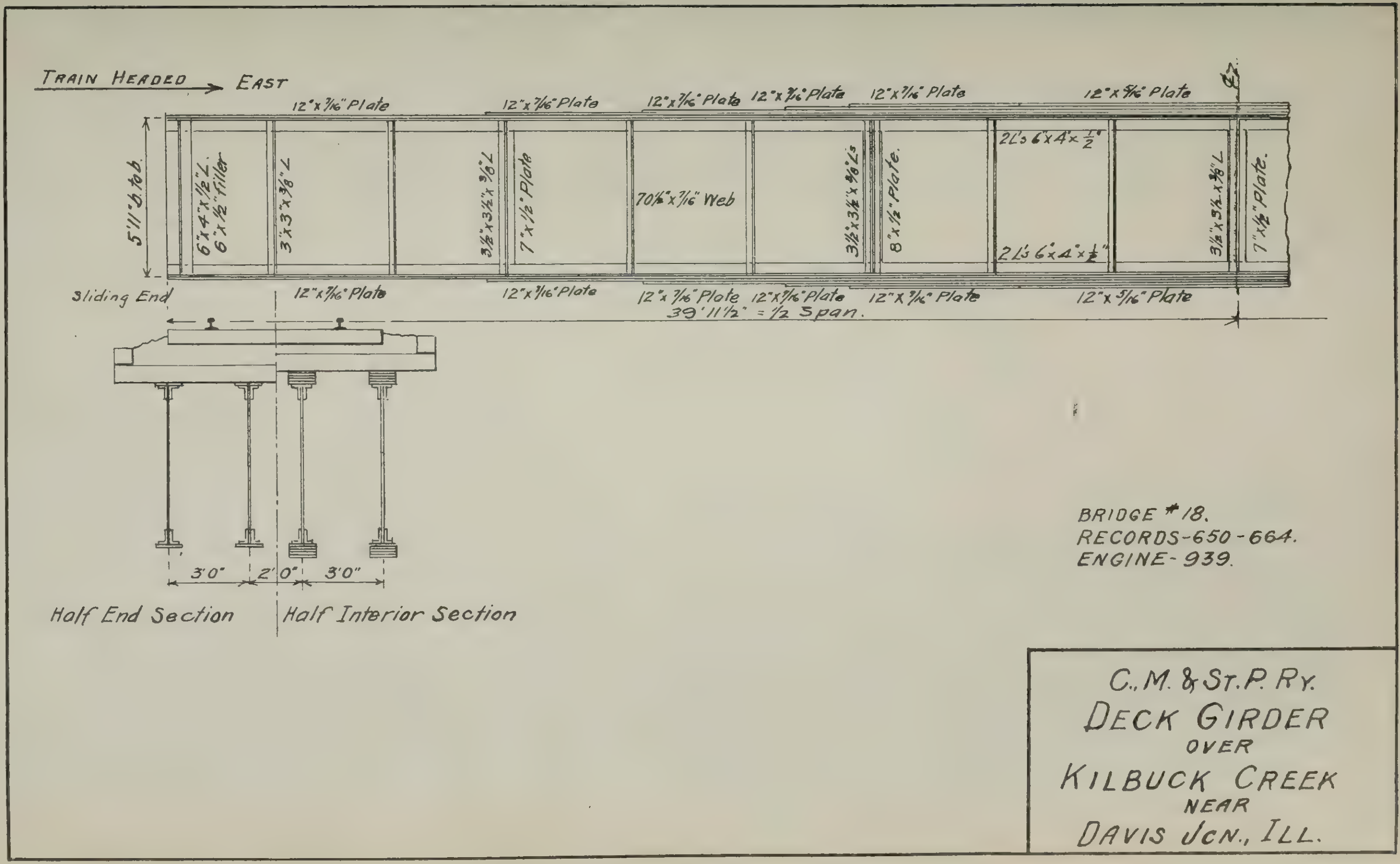
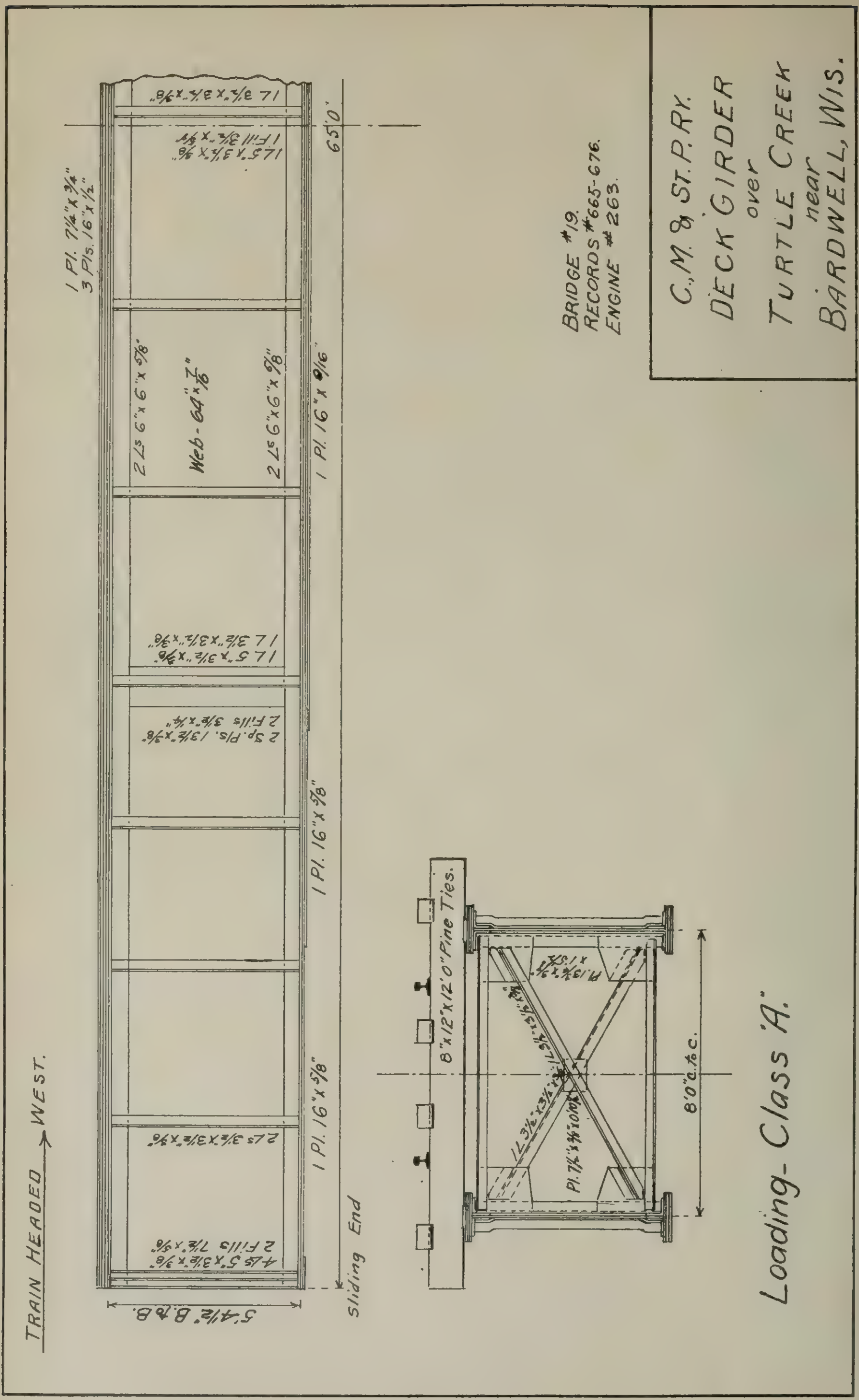
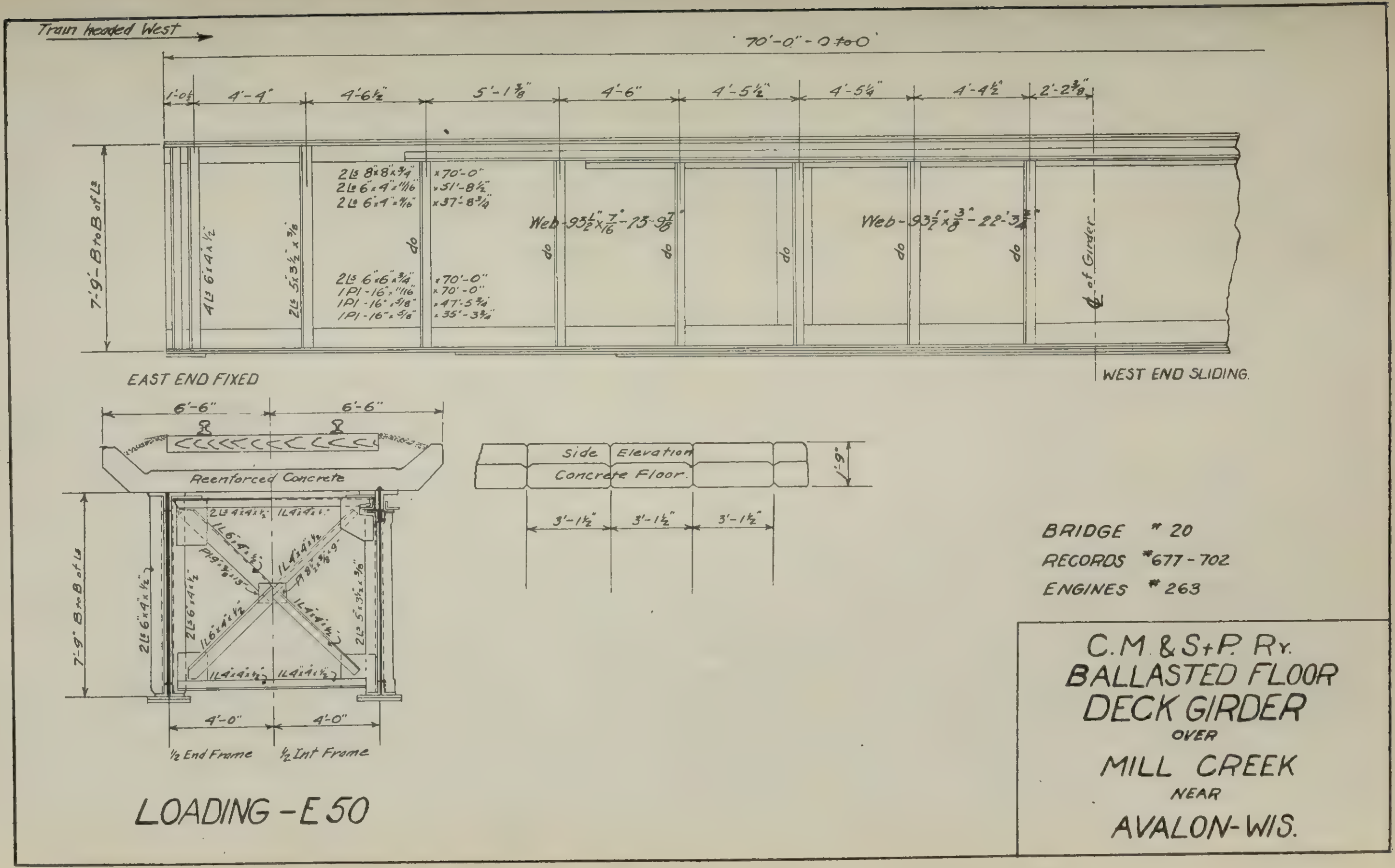
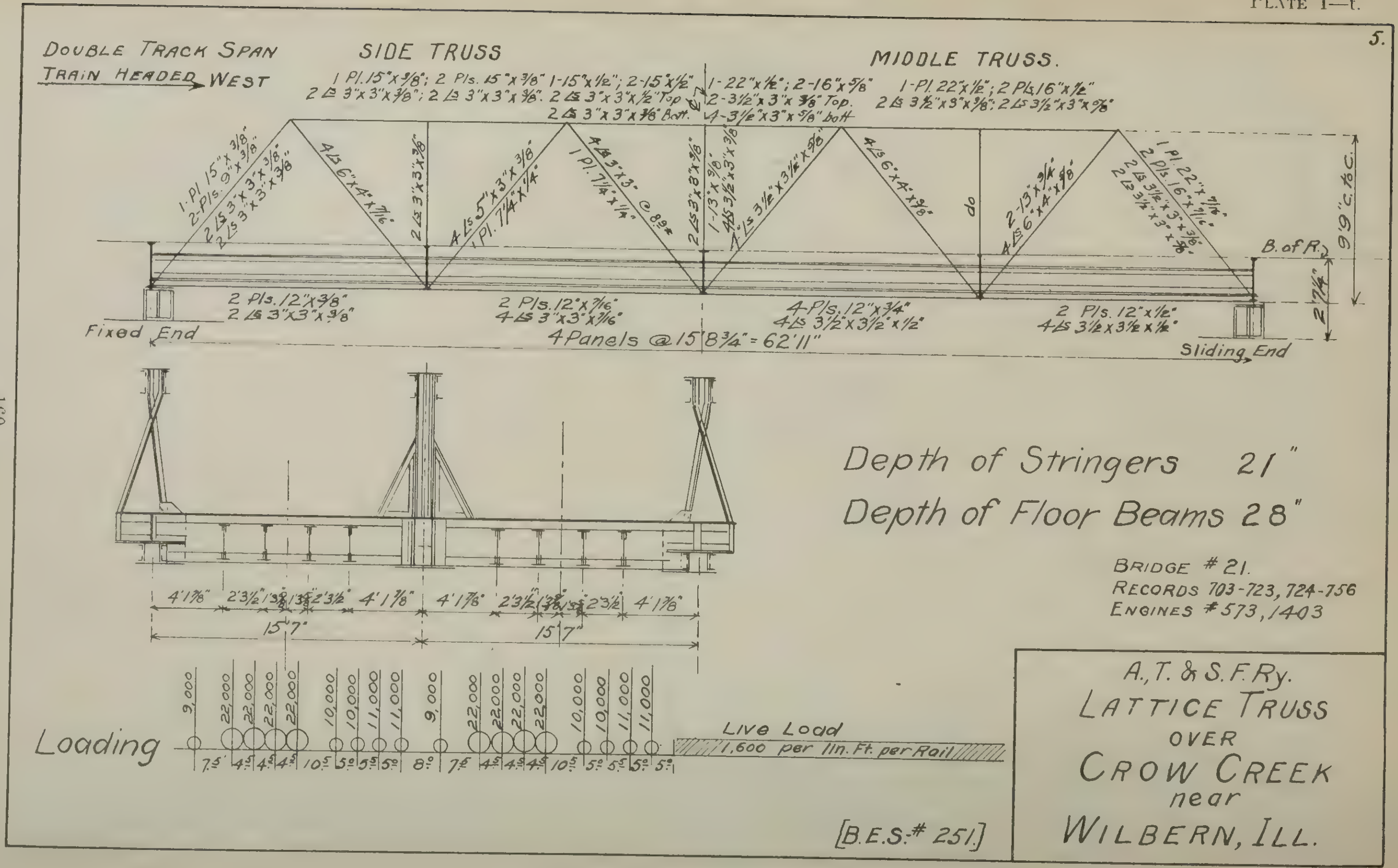
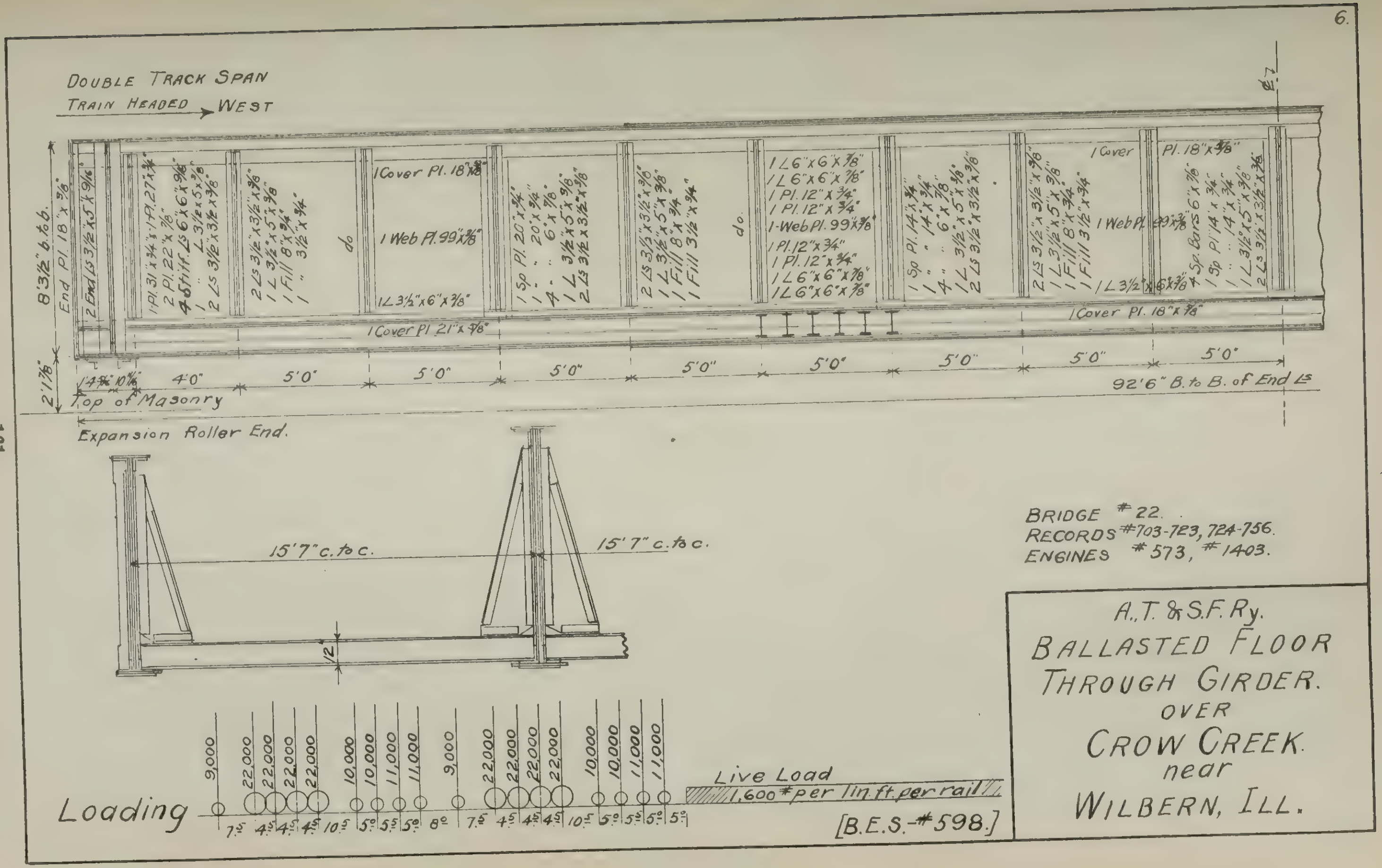

TRAIN HEADED → EAST
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x5/16" Plate
5'11" b to b.
6"x4"x1/2" L.
6"x1/2" filler
3"x3"x3/8" L
3 1/2"x3 1/2"x3/8" L
7"x1/2" Plate
70 1/2"x7/16" Web
3 1/2"x3 1/2"x3/8" L's
8"x1/2" Plate.
2L's 6"x4"x1/2"
2L's 6"x4"x1/2"
3 1/2"x3 1/2"x3/8" L
7"x1/2" Plate.
℄
Sliding End
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x7/16" Plate
12"x5/16" Plate
39' 11 1/2" = 1/2 Span.
3'0"
2'0"
3'0"
Half End Section
Half Interior Section
BRIDGE #18.
RECORDS-650-664.
ENGINE-939.
C., M. & ST. P. RY.
DECK GIRDER
OVER
KILBUCK CREEK
NEAR
DAVIS JCN., ILL.

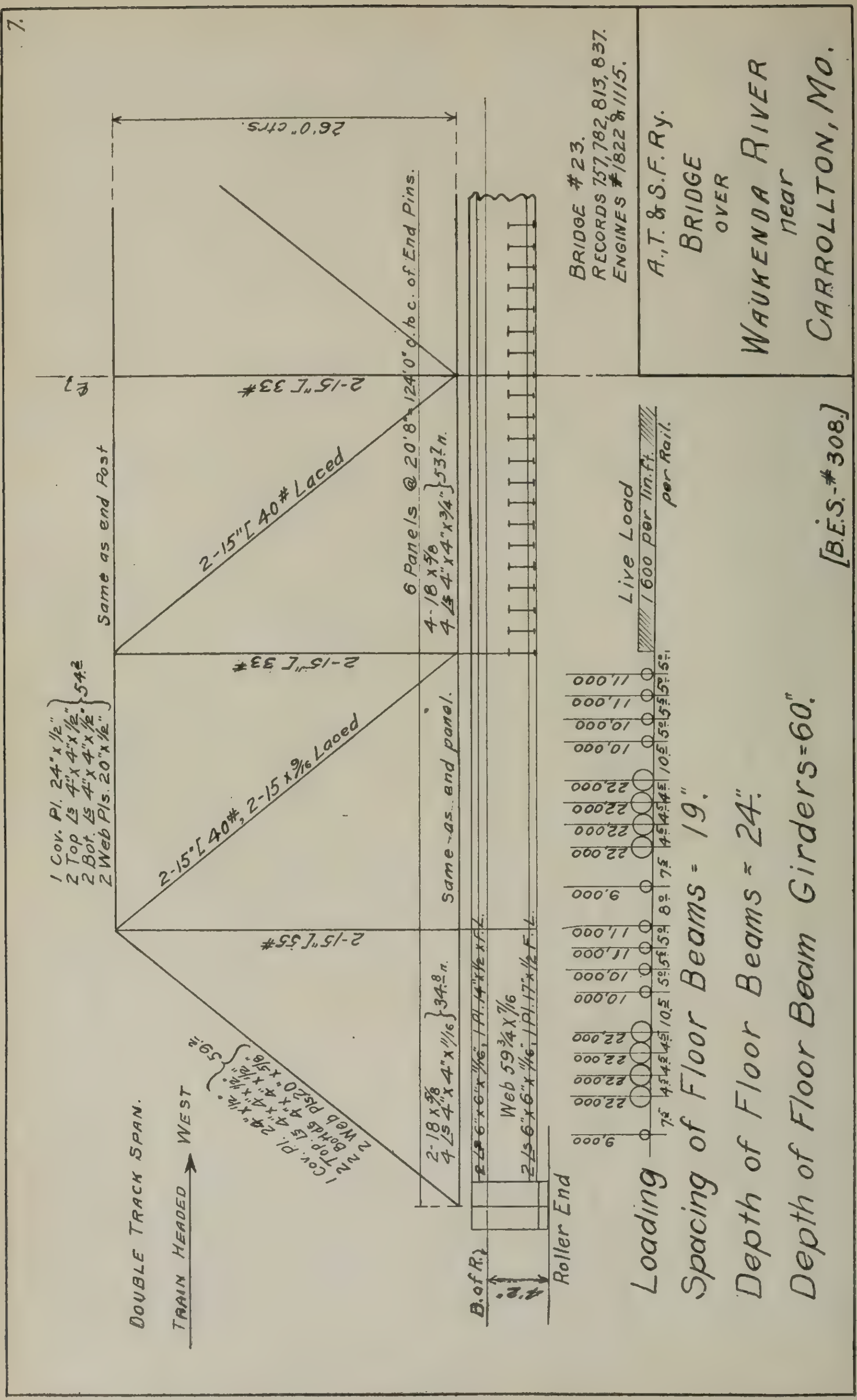
PLATE I—r.

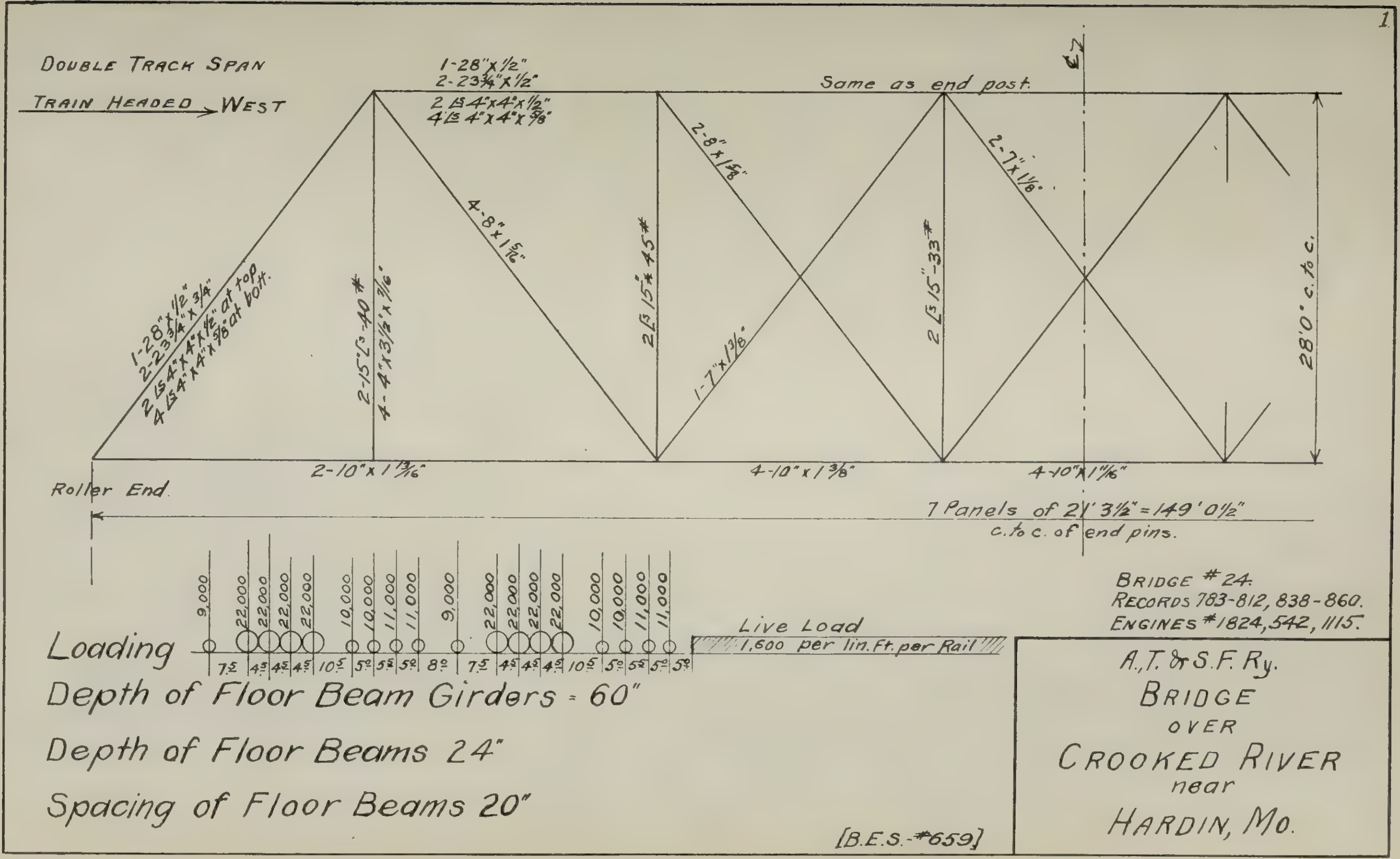

C., M. & St. P. Ry.
Deck Girder
over
Turtle Creek
near
Bardwell, Wis.
Bridge #19.
Records #665-676.
Engine #263.
1 Pl. 7¼"x¾"
3 Pls. 16"x½"
1 L 3½"x3½"x⅝"
1 Fill 3½"x¾"
1 L 5"x3½"x⅝"
65'0"
2Ls 6"x6"x⅝"
Web-64"x7/16"
2Ls 6"x6"x⅝"
1 Pl. 16"x9/16"
1 L 3½"x3½"x⅝"
1 L 5"x3½"x⅝"
2 Fills 3½"x¼"
2 Sp. Pls. 13½"x⅝"
1 Pl. 16"x⅝"
1 Pl. 16"x⅝"
2 Ls 3½"x3½"x⅝"
4 Ls 5"x3½"x⅝"
2 Fills 7½"x⅝"
5'-4½" B. to B.
Sliding End
Train Headed → West.
8"x12"x12'0" Pine Ties.
8'0" c. to c.
Pl. 13½"x⅜"x1'5"
1 L 3½"x3½"x⅜"
Pl. 7½"x⅜"x1'0"
Loading- Class 'A'.

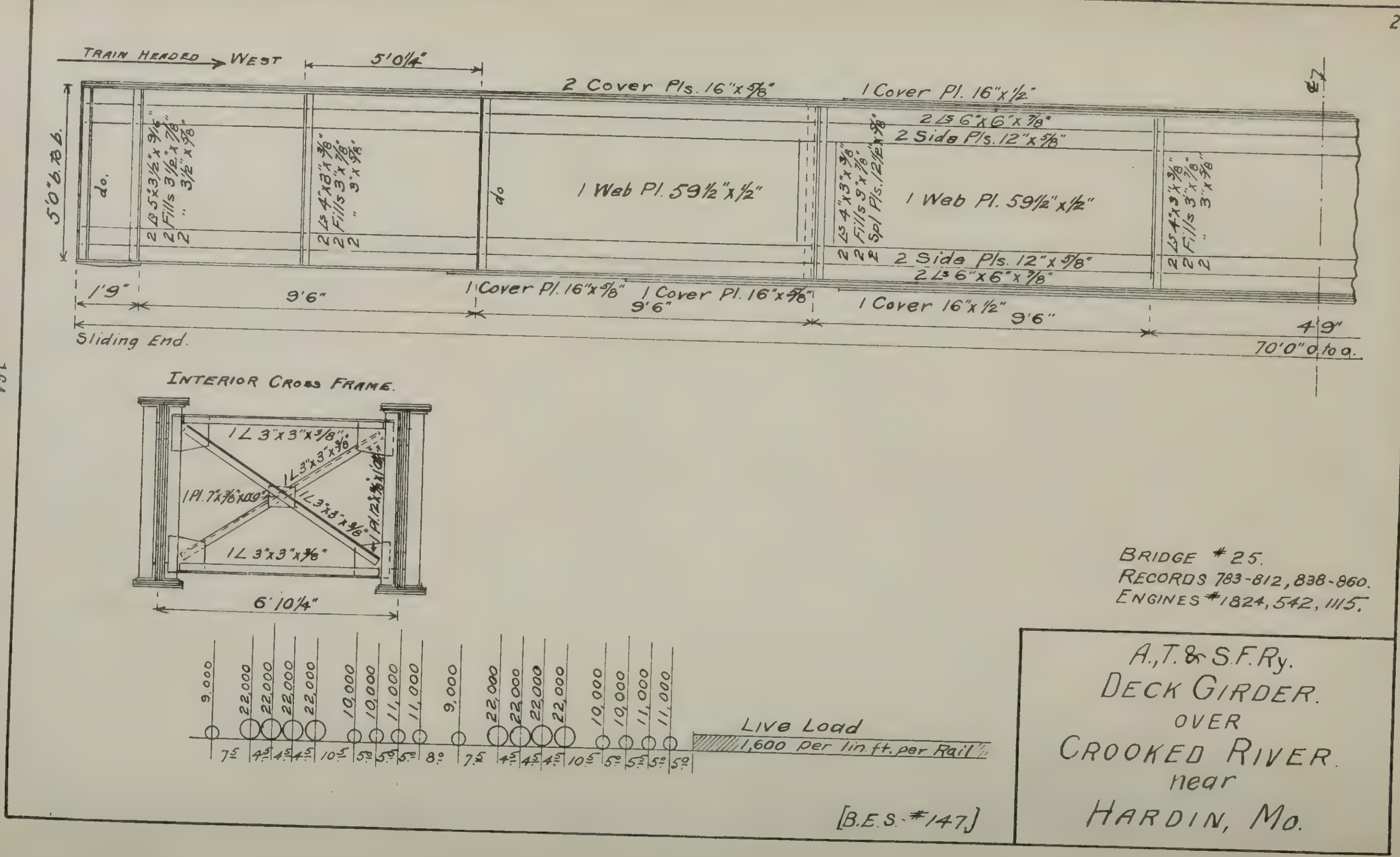

Train headed West
70'-0" - 0 to 0
1'-0½
4'-4"
4'-6½"
5'-1⅜"
4'-6"
4'-5½"
4'-5¼"
4'-4½"
2'-2⅜"
7'-9" - B to B of Ls
4 Ls 6 x 4 x ½
2 Ls 5 x 3½ x ⅜
2 Ls 8 x 8 x ¾ x 70'-0"
2 Ls 6 x 4 x 11/16 x 51'-8½"
2 Ls 6 x 4 x 9/16 x 37'-8¾"
2 Ls 6 x 6 x ¾ x 70'-0"
1 Pl - 16 x 11/16 x 70'-0"
1 Pl - 16 x ⅝ x 47'-5¾"
1 Pl - 16 x ⅝ x 35'-3¾"
do
Web - 93½ x 7/16 - 23'-9⅞"
Web - 93½ x ⅜ - 22'-3⅞"
℄ of Girder
EAST END FIXED
WEST END SLIDING.
6'-6"
6'-6"
Reenforced Concrete
Side Elevation
Concrete Floor.
1'-9"
3'-1½"
3'-1½"
3'-1½"
7'-9" B to B of Ls
2 Ls 6 x 4 x ½
2 Ls 4 x 4 x ½
1 L 4 x 4 x ½
1 L 6 x 4 x ½
Pl 9 x ⅜ x 15
1 L 4 x 4 x ½
Pl 8½ x ⅜ x 9
2 Ls 6 x 4 x ½
1 L 6 x 4 x ½
1 L 4 x 4 x ½
2 Ls 5 x 3½ x ⅜
1 L 4 x 4 x ½
1 L 4 x 4 x ½
4'-0"
4'-0"
½ End Frame
½ Int Frame
LOADING - E 50
BRIDGE # 20
RECORDS # 677 - 702
ENGINES # 263
C.M. & St.P. Ry.
BALLASTED FLOOR
DECK GIRDER
OVER
MILL CREEK
NEAR
AVALON-WIS.

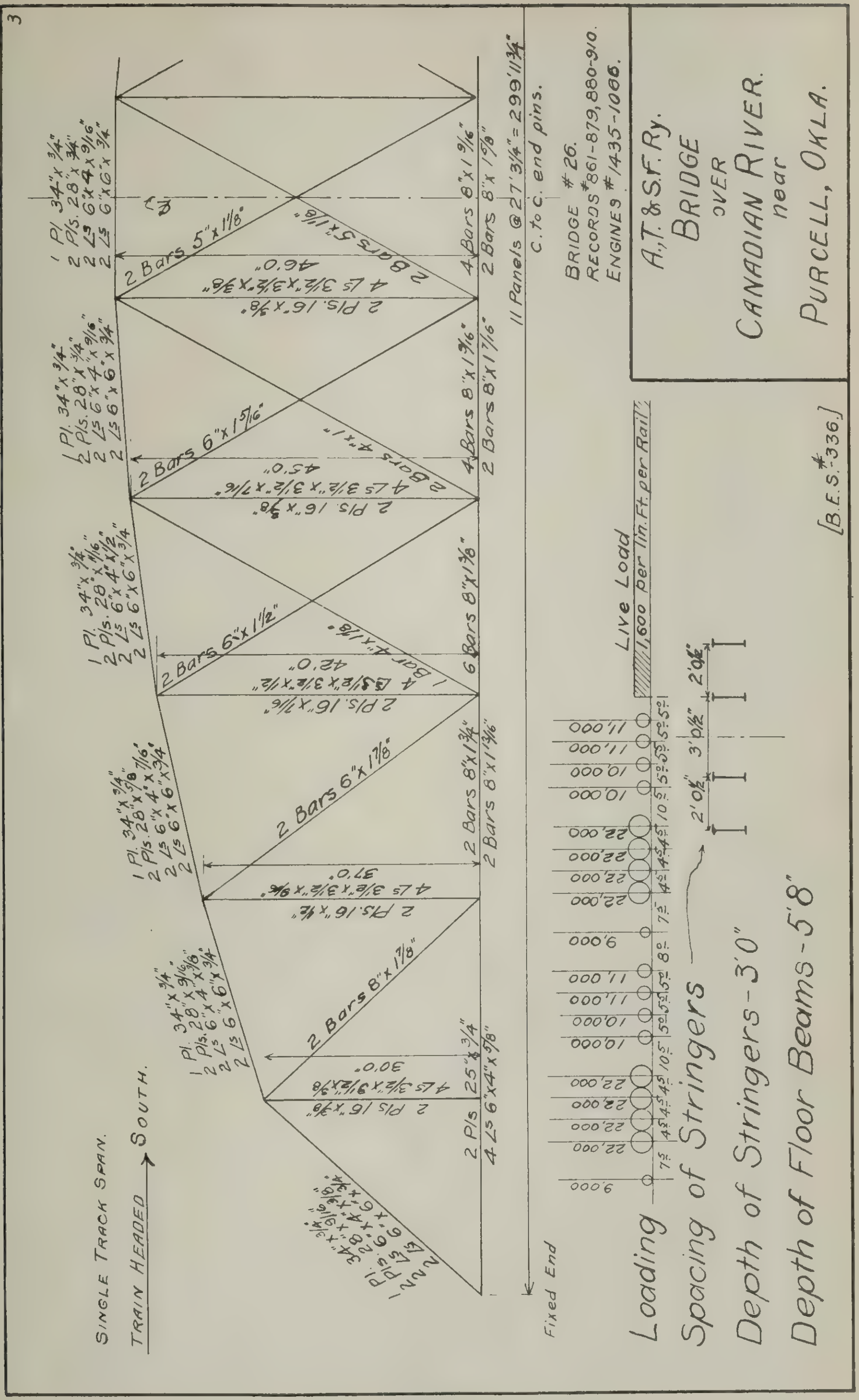

5.
DOUBLE TRACK SPAN
TRAIN HEADED WEST
SIDE TRUSS
MIDDLE TRUSS.
1 Pl. 15"x3/8"; 2 Pls. 15"x3/8" 1-15"x1/2"; 2-15"x1/2"
2 ∠s 3"x3"x3/8"; 2 ∠s 3"x3"x3/8". 2 ∠s 3"x3"x1/2" Top
2 ∠s 3"x3"x3/8" Bott.
1-22"x1/2"; 2-16"x5/8"
2-3½"x3"x3/8" Top.
4-3½"x3"x5/8" bott
1-Pl. 22"x1/2"; 2 Pls. 16"x1/2"
2 ∠s 3½"x3"x3/8"; 2 ∠s 3½"x3"x5/8"
1-Pl. 15"x3/8"
2-Pls. 9"x3/8"
2 ∠s 3"x3"x3/8"
2 ∠s 3"x3"x3/8"
4 ∠s 6"x4"x7/16"
2 ∠s 3"x3"x3/8"
4 ∠s 5"x3"x3/8"
1 Pl. 7¼"x¼"
4 ∠s 3"x3" @ 8.9#
1 Pl. 7¼"x¼"
2 ∠s 3"x8"x3/8"
1-13"x3/8"
4 ∠s 3½"x3"x3/8"
4 ∠s 3½"x3¼"x3/8"
4 ∠s 6"x4"x3/8"
do
2-13"x3/4"
4 ∠s 6"x4"x7/8"
1 Pl. 22"x7/16"
2 Pls. 16"x7/16"
2 ∠s 3½"x3"x3/8"
2 ∠s 3½"x3"x3/8"
B. of R.
9'9" c. to c.
2'7¼"
2 Pls. 12"x3/8"
2 ∠s 3"x3"x3/8"
2 Pls. 12"x7/16"
4 ∠s 3"x3"x7/16"
4 Pls. 12"x3/4"
4 ∠s 3½"x3½"x1/2"
2 Pls. 12"x1/2"
4 ∠s 3½x3½x1/2"
Fixed End
4 Panels @ 15'8¾" = 62'11"
Sliding End
4'1⅞"
2'3½"
1'3⅜"
1'3⅜"
2'3½"
4'1⅞"
4'1⅞"
2'3½"
1'3⅜"
1'3⅜"
2'3½"
4'1⅞"
15'7"
15'7"
Depth of Stringers 21"
Depth of Floor Beams 28"
BRIDGE # 21.
RECORDS 703-723, 724-756
ENGINES # 573, 1403
Loading
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
8.0
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
5.0
Live Load
1,600 per lin. Ft. per Rail
[B.E.S. # 251.]
A., T. & S. F. Ry.
LATTICE TRUSS
OVER
CROW CREEK
near
WILBERN, ILL.

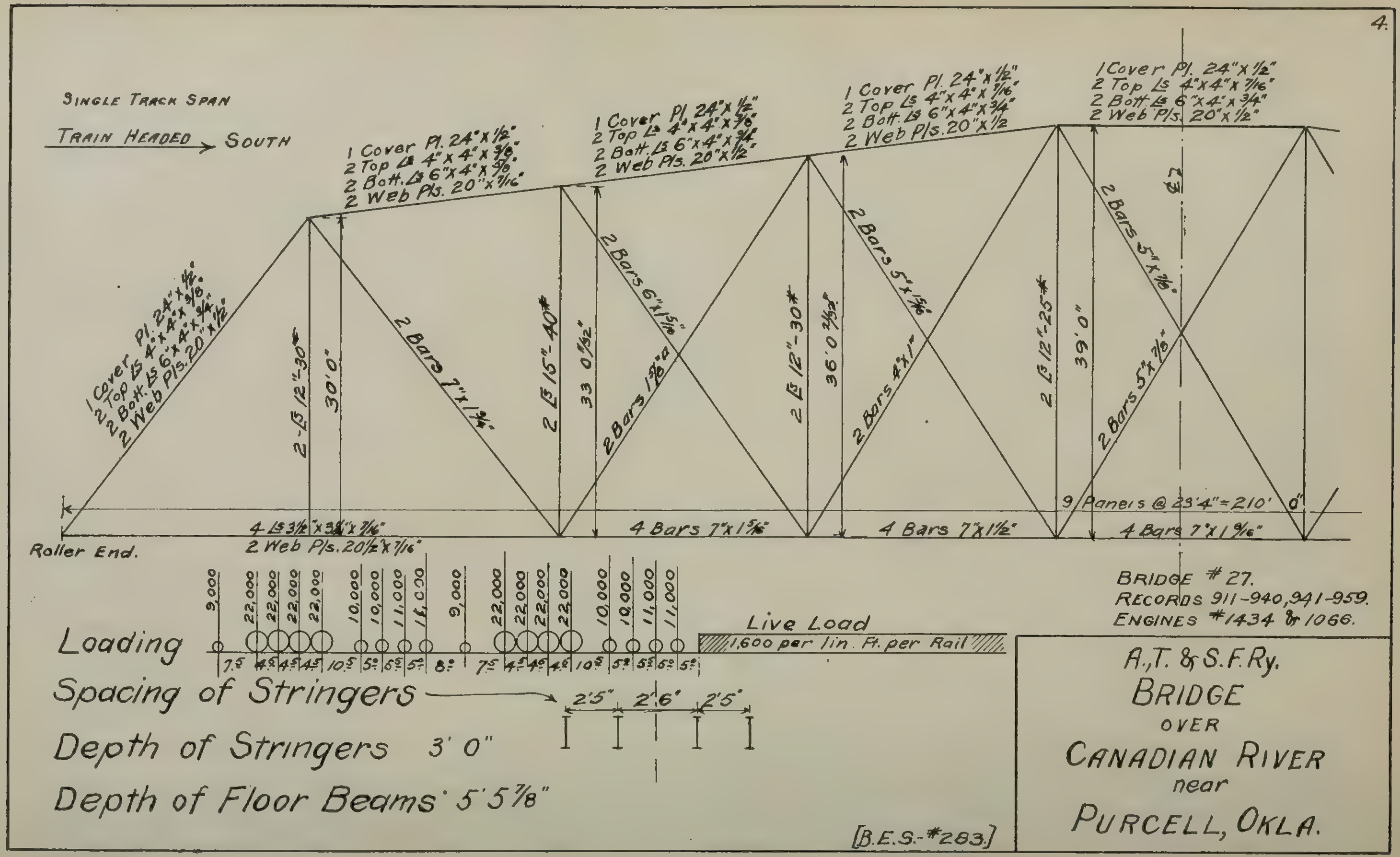

6.
DOUBLE TRACK SPAN
TRAIN HEADED → WEST
8'3½" b. to b.
End Pl. 18" x ⅜"
2 End ∟s 3½" x 5" x 9/16
1-Pl. 31" x ¾" & 1-Pl. 27" x ¾"
2 Pl. 22" x ⅞"
4 Stiff. ∟s 6" x 6" x 9/16"
1 " ∟ 3½ x 5 x ⅜
2 ∟s 3½" x 3½" x ⅜"
2 ∟s 3½" x 3½" x ⅜"
1 ∟ 3½" x 5" x ⅜
1 Fill 8" x ¾"
1 " 3½" x ¾"
do
1 Cover Pl. 18" x ⅜"
1 Web Pl. 99" x ⅜"
1 ∟ 3½" x 6" x ⅜"
1 Cover Pl 21" x ⅜"
1 Sp. Pl. 20" x ¾"
1 " " 20" x ¾
4 " " 6" x ⅞
1 ∟ 3½" x 5" x ⅜
2 ∟s 3½ x 3½" x ⅜
2 ∟s 3½" x 3½" x ⅜"
1 ∟ 3½" x 5" x ⅜"
1 Fill 8" x ¾"
1 Fill 3½" x ¾"
do.
1 ∟ 6" x 6" x ⅞"
1 ∟ 6" x 6" x ⅞"
1 Pl. 12" x ¾"
1 Pl. 12" x ¾"
1-Web Pl. 99" x ⅜"
1 Pl. 12" x ¾"
1 Pl. 12" x ¾"
1 ∟ 6" x 6" x ⅞"
1 ∟ 6" x 6" x ⅞"
1 Sp. Pl. 14" x ¾"
1 " " 14" x ¾"
4 " " 6" x ⅞"
1 ∟ 3½" x 5" x ⅜"
2 ∟s 3½" x 3½" x ⅜
2 ∟s 3½" x 3½" x ⅜"
1 ∟ 3½" x 5" x ⅜
1 Fill 8" x ¾"
1 Fill 3½" x ¾"
1 Cover Pl. 18" x ⅜"
1 Web Pl. 99" x ⅜"
1 ∟ 3½" x 6" x ⅜"
4 Sp. Bars 6" x ⅞"
1 Sp. Pl. 14" x ¾"
1 " " 14" x ¾"
1 ∟ 3½" x 5" x ⅜"
2 ∟s 3½" x 3½" x ⅜"
1 Cover Pl. 18" x ⅜"
℄
2'1⅞"
1'4⅝" 10¹¹⁄₁₆"
4'0"
5'0"
5'0"
5'0"
5'0"
5'0"
5'0"
5'0"
5'0"
92'6" B. to B. of End ∟s
Top of Masonry
Expansion Roller End.
15'7" c. to c.
15'7" c. to c.
12
BRIDGE #22.
RECORDS #703-723, 724-756.
ENGINES #573, #1403.
Loading
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
7.5 4.5 4.5 4.5 10.5 5.0 5.5 5.0 8.0 7.5 4.5 4.5 4.5 10.5 5.0 5.5 5.0 5.0
Live Load
1,600# per lin. ft. per rail
[B.E.S.-#598.]
A., T. & S.F. Ry.
BALLASTED FLOOR
THROUGH GIRDER.
OVER
CROW CREEK.
near
WILBERN, ILL.

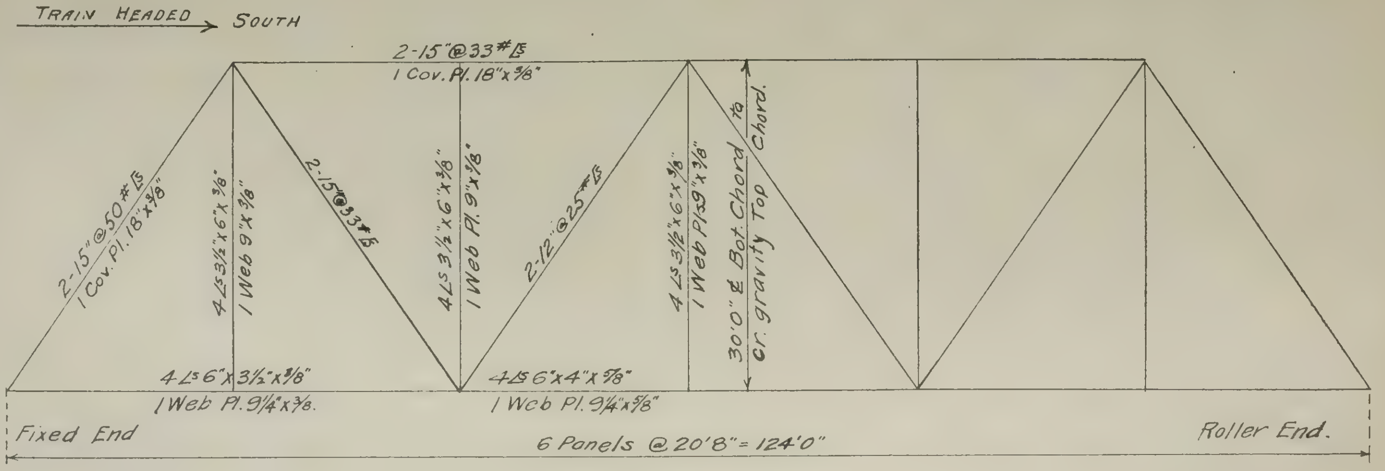

7.
DOUBLE TRACK SPAN.
TRAIN HEADED → WEST
1 Cov. Pl. 24"x 1/2", 2 Top Ls 4"x4"x1/2", 2 Bot. Ls 4"x4"x1/2", 2 Web Pls. 20"x1/2" } 54.2
Same as end Post
26.0" ctrs.
2-15"[40#, 2-15 x 9/16 Laced
2-15"[40# Laced
2-15"[55#
2-15"[33#
2-15"[33#
℄
6 Panels @ 20'8" = 124'0" c. to c. of End Pins.
4-18 x 5/8, 4 Ls 4"x4"x3/4" } 53.2 n.
Same as end panel.
2-18 x 5/8, 4 Ls 4"x4"x11/16 } 34.8 n.
1 Cov. Pl. 24"x1/2", 2 Top Ls 4"x4"x1/2", 2 Bot. Ls 4"x4"x1/2", 2 Web Pls. 20"x5/16" } 59.2 n.
2 Ls 6"x6"x11/16, 1 Pl. 14"x1/2"x F.L.
Web 59 3/4 x 7/16
2 Ls 6"x6"x11/16, 1 Pl. 17"x1/2" F.L.
B. of R.
7.4
Roller End
Loading
9,000 22,000 22,000 22,000 22,000 10,000 10,000 11,000 11,000 9,000 22,000 22,000 22,000 22,000 10,000 10,000 11,000 11,000
7.5 4.5 4.5 4.5 10.5 5.0 5.0 5.0 8.0 7.5 4.5 4.5 4.5 10.5 5.0 5.0 5.0 5.0
Live Load
1600 per lin. ft.
per Rail.
Spacing of Floor Beams = 19".
Depth of Floor Beams = 24".
Depth of Floor Beam Girders = 60".
BRIDGE #23.
RECORDS 757, 782, 813, 837.
ENGINES #1822 & 1115.
A., T. & S.F. Ry.
BRIDGE
OVER
WAUKENDA RIVER
near
CARROLLTON, MO.
[B.E.S.-#308.]


1
DOUBLE TRACK SPAN
TRAIN HEADED → WEST
1-28"x1/2"
2-23¾"x1/2"
2 ∠s 4"x4"x1/2"
4 ∠s 4"x4"x5/8"
Same as end post.
1-28"x1/2"
2-23¾"x3/4"
2 ∠s 4"x4"x1/2" at top
4 ∠s 4"x4"x5/8" at bott.
2-15" [s -40#
4-4"x3½"x7/16"
4-8"x1 5/16"
2 [s 15"-45#
2-8"x1 5/8"
1-7"x1 3/8"
2 [s 15"-33#
2-7"x1 1/8"
℄
28'0" c. to c.
2-10"x1 13/16"
4-10"x1 3/8"
4-10"x1 11/16"
Roller End.
7 Panels of 21' 3½" = 149' 0½"
c. to c. of end pins.
BRIDGE #24.
RECORDS 783-812, 838-860.
ENGINES #1824, 542, 1115.
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
Live Load
1,600 per lin. Ft. per Rail
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
8.0
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
5.0
Loading
Depth of Floor Beam Girders = 60"
Depth of Floor Beams 24"
Spacing of Floor Beams 20"
[B.E.S.-#659]
A., T. & S. F. Ry.
BRIDGE
OVER
CROOKED RIVER
near
HARDIN, MO.


2
TRAIN HEADED → WEST
5'0¼"
2 Cover Pls. 16"x⅝"
1 Cover Pl. 16"x½"
2 Ls 6"x6"x⅞"
2 Side Pls. 12"x⅝"
5'0" B. to B.
do.
2 Ls 5"x3½"x9/16"
2 Fills 3½"x⅞"
2 " 3½"x⅝"
2 Ls 4"x3"x⅜"
2 Fills 3"x⅞"
2 " 3"x⅝"
do
1 Web Pl. 59½"x½"
2 Ls 4"x3"x⅜"
2 Fills 3"x⅞"
2 Spl Pls. 12½"x⅝"
1 Web Pl. 59½"x½"
2 Ls 4"x3"x⅜"
2 Fills 3"x⅞"
2 " 3"x⅝"
2 Side Pls. 12"x⅝"
2 Ls 6"x6"x⅞"
1'9"
9'6"
1 Cover Pl. 16"x⅝"
1 Cover Pl. 16"x⅝"
9'6"
1 Cover 16"x½"
9'6"
4'9"
70'0" c to c.
Sliding End.
INTERIOR CROSS FRAME.
1∠ 3"x3"x⅜"
1∠ 3"x3"x⅜"
1Pl. 7"x⅜"x0'9"
1∠ 3"x3"x⅜"
1Pl. 12"x⅜"x1'0"
1∠ 3"x3"x⅜"
6'10¼"
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
8.0
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
5.0
Live Load
1,600 per lin. ft. per Rail
BRIDGE #25.
RECORDS 783-812, 838-860.
ENGINES #1824, 542, 1115.
A., T. & S. F. Ry.
DECK GIRDER.
OVER
CROOKED RIVER.
near
HARDIN, Mo.
[B.E.S.-#147.]


3
Single Track Span.
Train Headed → South.
Fixed End
1 Pl. 34"x3/4"
2 Pls. 28"x3/4"
2 Ls 6"x4"x9/16"
2 Ls 6"x6"x3/4"
1 Pl. 34"x3/4"
2 Pls. 28"x9/16"
2 Ls 6"x4"x9/16"
2 Ls 6"x6"x3/4"
1 Pl. 34"x3/4"
2 Pls. 28"x7/16"
2 Ls 6"x4"x3/4"
2 Ls 6"x6"x3/4"
1 Pl. 34"x3/4"
2 Pls. 28"x11/16"
2 Ls 6"x4"x1/2"
2 Ls 6"x6"x3/4"
1 Pl. 34"x3/4"
2 Pls. 28"x3/4"
2 Ls 6"x4"x9/16"
2 Ls 6"x6"x3/4"
1 Pl. 34"x3/4"
2 Pls. 28"x3/4"
2 Ls 6"x4"x9/16"
2 Ls 6"x6"x3/4"
2 Bars 8"x1 1/8"
2 Bars 6"x1 7/8"
2 Bars 6"x1 1/2"
2 Bars 6"x1 5/16"
2 Bars 5"x1 1/8"
2 Bars 5"x1 1/8"
2 Bars 4"x1"
1 Bar 4"x1 1/8"
2 Pls 16"x3/8"
4 Ls 3 1/2"x3 1/2"x3/8
30.0"
2 Pls. 16"x1/2"
4 Ls 3 1/2"x3 1/2"x9/16"
37.0"
2 Pls. 16"x7/16"
4 Ls 3 1/2"x3 1/2"x1/2"
42.0"
2 Pls. 16"x3/8"
4 Ls 3 1/2"x3 1/2"x7/16"
45.0"
2 Pls. 16"x3/8"
4 Ls 3 1/2"x3 1/2"x3/8"
46.0"
2 Pls 25"x3/4"
4 Ls 6"x4"x5/8"
2 Bars 8"x1 3/4"
2 Bars 8"x1 9/16"
6 Bars 8"x1 7/8"
4 Bars 8"x1 9/16"
2 Bars 8"x1 7/16"
4 Bars 8"x1 9/16"
2 Bars 8"x1 5/8"
℄
11 Panels @ 27'3 3/4" = 299'11 3/4"
C. to C. end pins.
BRIDGE #26.
RECORDS #861-879, 880-910.
ENGINES #1435-1086.
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
7.5 4.5 4.5 4.5 10.5 5.0 5.5 5.0 8.0 7.5 4.5 4.5 4.5 10.5 5.0 5.5 5.0
Live Load
1,600 per lin. Ft. per Rail.
Loading
Spacing of Stringers
2'0 1/2"
3'0 1/2"
2'0 1/2"
Depth of Stringers - 3'0"
Depth of Floor Beams - 5'8"
A.T.&S.F. Ry.
BRIDGE
over
CANADIAN RIVER
near
PURCELL, OKLA.
[B.E.S. #336.]


4.
SINGLE TRACK SPAN
TRAIN HEADED → SOUTH
1 Cover Pl. 24"x½"
2 Top Ls 4"x4"x⅜"
2 Bott. Ls 6"x4"x¾"
2 Web Pls. 20"x½"
1 Cover Pl. 24"x½"
2 Top Ls 4"x4"x⅜"
2 Bott. Ls 6"x4"x⅝"
2 Web Pls. 20"x9/16"
1 Cover Pl. 24"x½"
2 Top Ls 4"x4"x⅜"
2 Bott. Ls 6"x4"x¾"
2 Web Pls. 20"x½"
1 Cover Pl. 24"x½"
2 Top Ls 4"x4"x7/16"
2 Bott. Ls 6"x4"x¾"
2 Web Pls. 20"x½
1 Cover Pl. 24"x½"
2 Top Ls 4"x4"x7/16"
2 Bott. Ls 6"x4"x¾"
2 Web Pls. 20"x½"
2-[12"-30#
30'0"
2 Bars 7"x1¾"
2 [15"-40#
33 0 1/32"
2 Bars 6"x1 5/16"
2 Bars 1⅝"ø
2 [12"-30#
36'0 21/32"
2 Bars 5"x1 5/16"
2 Bars 4"x1"
2 [12"-25#
39'0"
2 Bars 5"x7/16"
2 Bars 5"x7/16"
℄
9 Panels @ 23'4" = 210' 0"
4 Ls 3½"x3½"x7/16"
2 Web Pls. 20½"x7/16"
4 Bars 7"x1 5/16"
4 Bars 7"x1½"
4 Bars 7"x1 9/16"
Roller End.
BRIDGE #27.
RECORDS 911-940, 941-959.
ENGINES #1434 & 1066.
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
9,000
22,000
22,000
22,000
22,000
10,000
10,000
11,000
11,000
Live Load
1,600 per lin. Ft. per Rail
Loading
7.5
4.5
4.5
4.5
10.5
5.0
6.5
5.0
8.0
7.5
4.5
4.5
4.5
10.5
5.0
5.5
5.0
5.0
Spacing of Stringers →
2'5"
2'6"
2'5"
Depth of Stringers 3' 0"
Depth of Floor Beams 5' 5⅞"
[B.E.S.-#283.]
A., T. & S. F. Ry.
BRIDGE
OVER
CANADIAN RIVER
near
PURCELL, OKLA.



BRIDGE #28.
RECORDS 960-995, 996-1026.
Engine #1746.

Loading :- ?

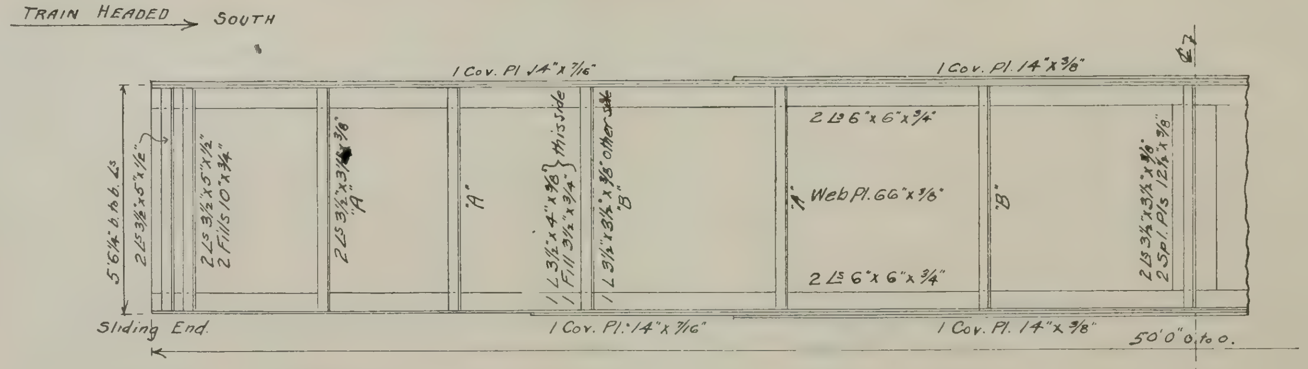
Spacing of Stringers 7' 6"

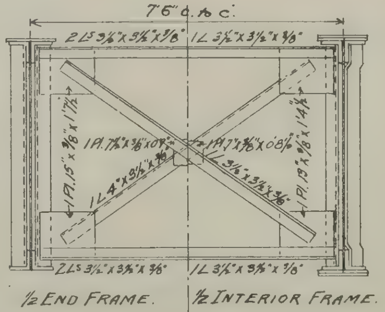
Depth of Stringers 34½" b. to b. ∠s.

Depth of Floor Beams 48½" b. to b. ∠s.

C., R.I. & P. RY.
RIVETED TRUSS SPAN
over
NINNESCAH RIVER
near
ZYBA, KANSAS.

PLATE I—ab.

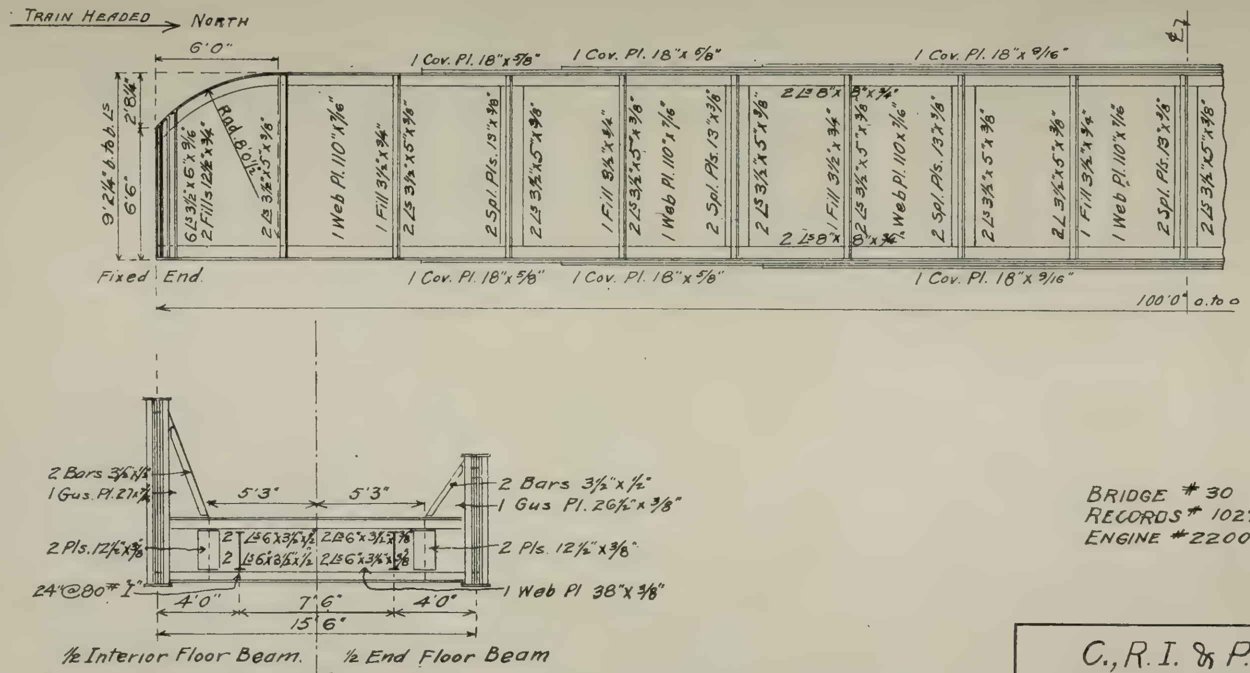




BRIDGE #29.
RECORDS 960 - 995, 996 - 1026
ENGINE #1746.

C., R.I. & P. RY.
DECK GIRDER.
over
NINNESCAH RIVER.
near
ZYBA, KANSAS.

Loading:- C., R.I. & P. Spec. of 1903.

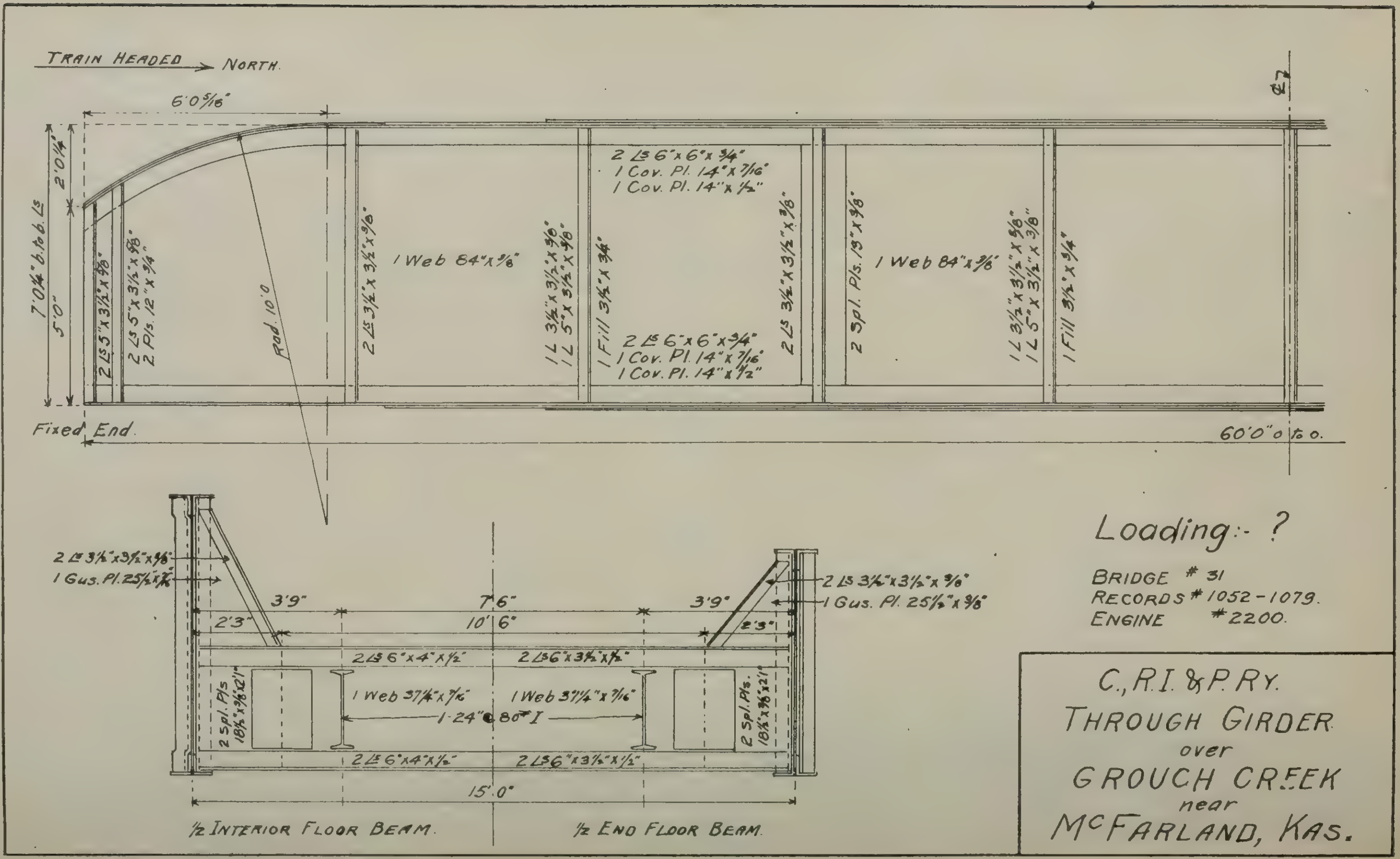


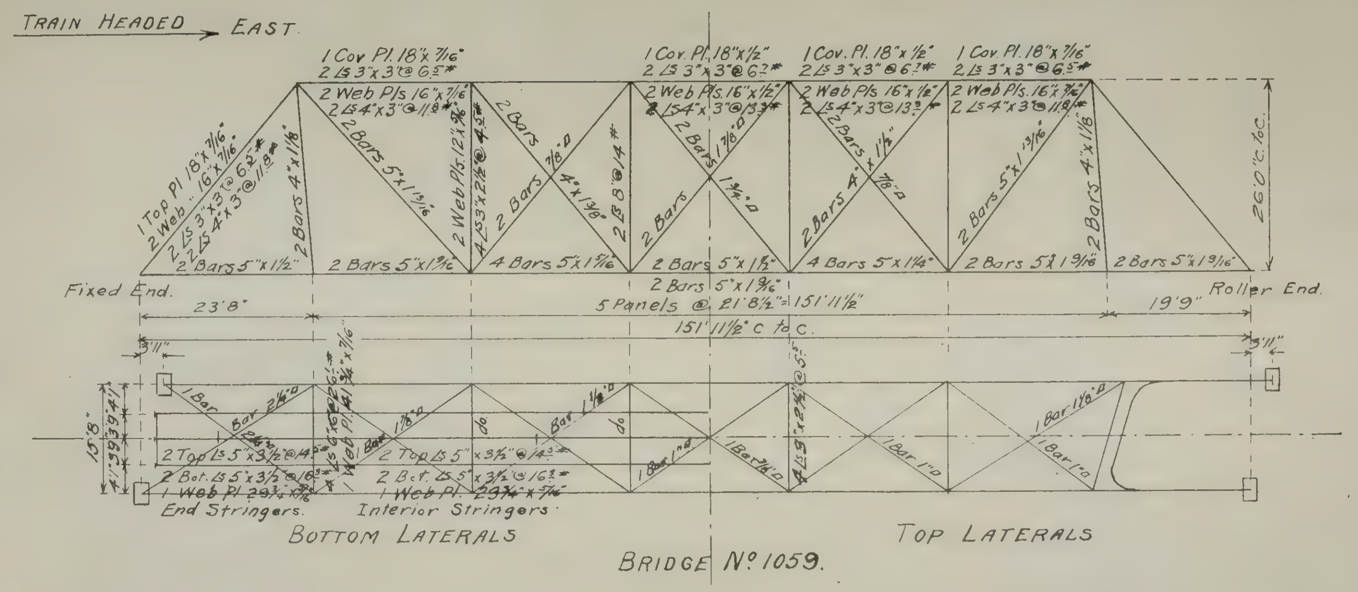
BRIDGE # 30
RECORDS # 1027-1051.
ENGINE # 2200

Loading :- ?

C., R. I. & P. Ry.
THROUGH GIRDER
over
MILL CREEK
near
ALMA, KANSAS.

PLATE I—ad.


TRAIN HEADED → NORTH.
6'0 5/16"
2'0 1/4"
7'0 1/4" b. to b. Ls
5'0"
2 Ls 5" x 3 1/2" x 3/8"
2 Ls 5" x 3 1/2" x 3/8"
2 Pls. 12" x 3/4"
Rad. 10.0
2 Ls 3 1/2" x 3 1/2" x 3/8"
1 Web 84" x 3/8"
1 L 3 1/2" x 3 1/2" x 3/8"
1 L 5" x 3 1/2" x 3/8"
1 Fill 3 1/2" x 3/4"
2 Ls 6" x 6" x 3/4"
1 Cov. Pl. 14" x 7/16"
1 Cov. Pl. 14" x 1/2"
2 Ls 6" x 6" x 3/4"
1 Cov. Pl. 14" x 7/16"
1 Cov. Pl. 14" x 1/2"
2 Ls 3 1/2" x 3 1/2" x 3/8"
2 Spl. Pls. 13" x 3/8"
1 Web 84" x 3/8"
1 L 3 1/2" x 3 1/2" x 3/8"
1 L 5" x 3 1/2" x 3/8"
1 Fill 3 1/2" x 3/4"
℄
Fixed End.
60'0" c. to c.
2 Ls 3 1/2" x 3 1/2" x 3/8"
1 Gus. Pl. 25 1/2" x 3/8"
3'9"
7'6"
3'9"
2'3"
10'6"
2'3"
2 Ls 3 1/2" x 3 1/2" x 3/8"
1 Gus. Pl. 25 1/2" x 3/8"
2 Ls 6" x 4" x 1/2"
2 Ls 6" x 3 1/2" x 1/2"
2 Spl. Pls. 18 1/2" x 3/8" x 21"
1 Web 37 1/4" x 7/16"
1 Web 37 1/4" x 7/16"
1-24" @ 80# I
2 Spl. Pls. 18 1/2" x 3/8" x 21"
2 Ls 6" x 4" x 1/2"
2 Ls 6" x 3 1/2" x 1/2"
15'0"
1/2 INTERIOR FLOOR BEAM.
1/2 END FLOOR BEAM.
Loading:- ?
BRIDGE # 31
RECORDS # 1052-1079.
ENGINE # 2200.
C., R.I. & P. RY.
THROUGH GIRDER
over
GROUCH CREEK
near
McFARLAND, KAS.



Loading:- Not known.

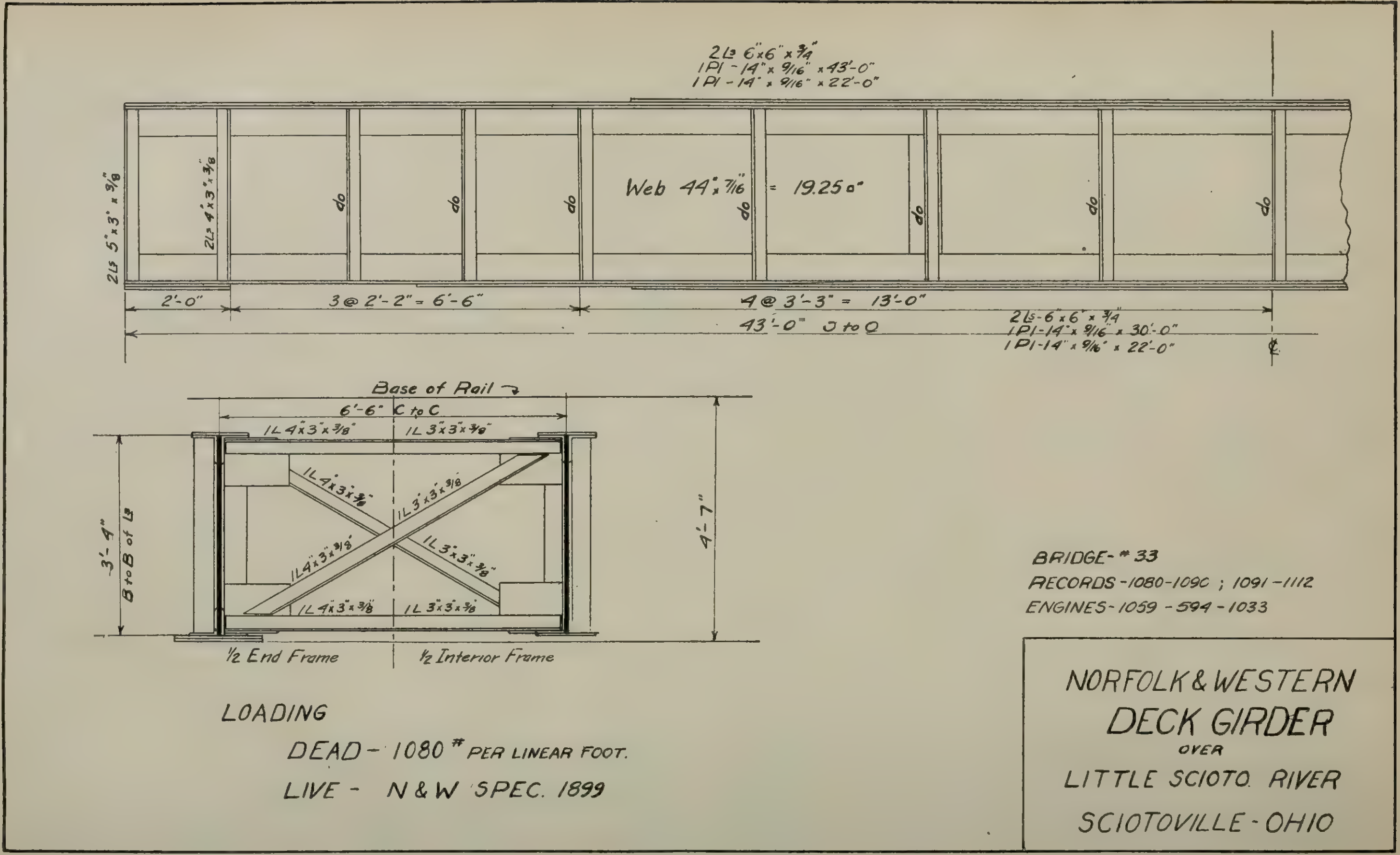
Spacing of Stringers 3'9" 3'9"

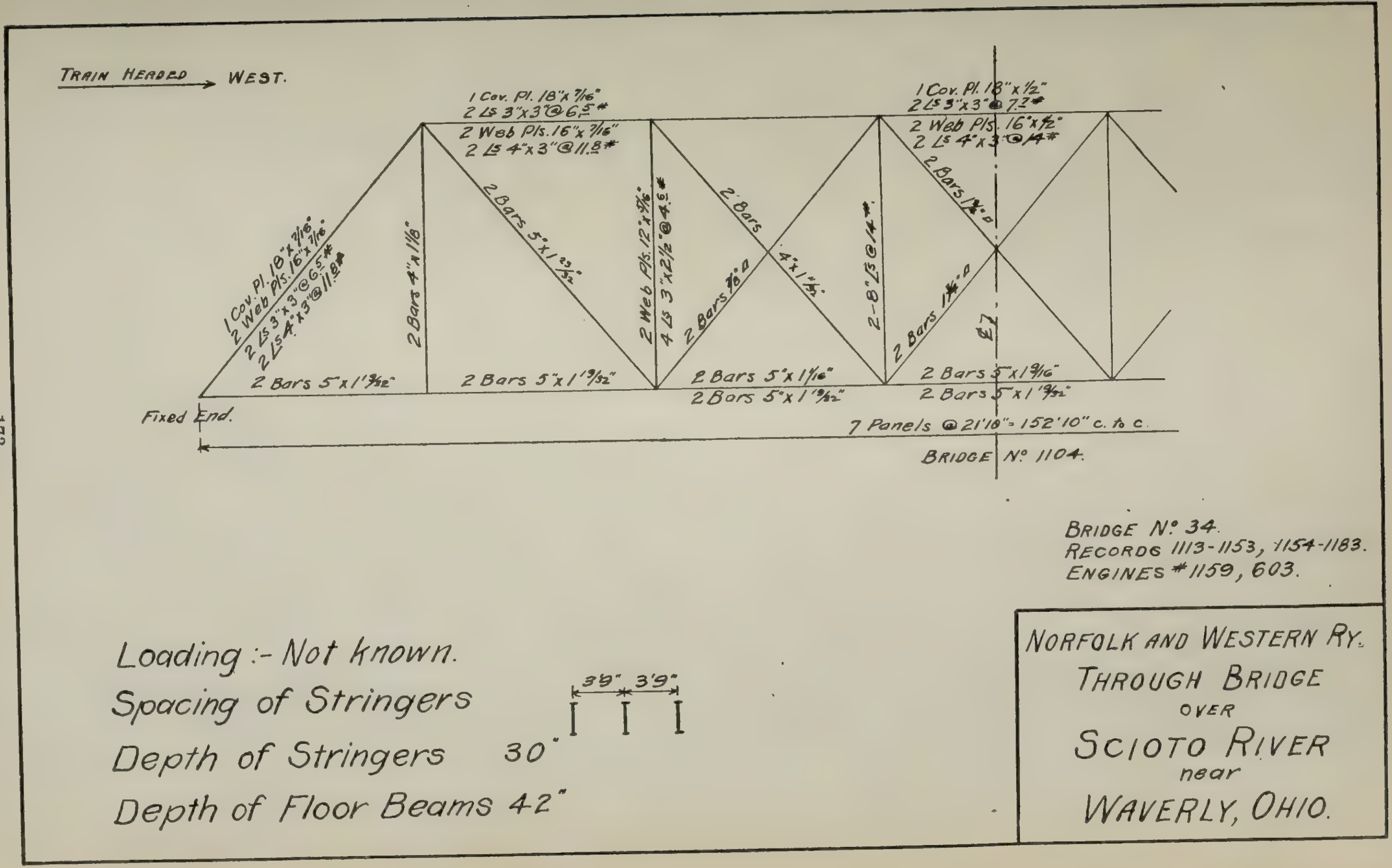
Depth of Stringers 30"

Depth of Floor Beams 42"

Bridge No. 32.
Records 1080-1090, 1091-1112.
Engines 1059, 594, 1033.

NORFOLK AND WESTERN RY.
SKEW THROUGH BRIDGE
OVER
LITTLE SCIOTO RIVER
near
SCIOTOVILLE, OHIO.

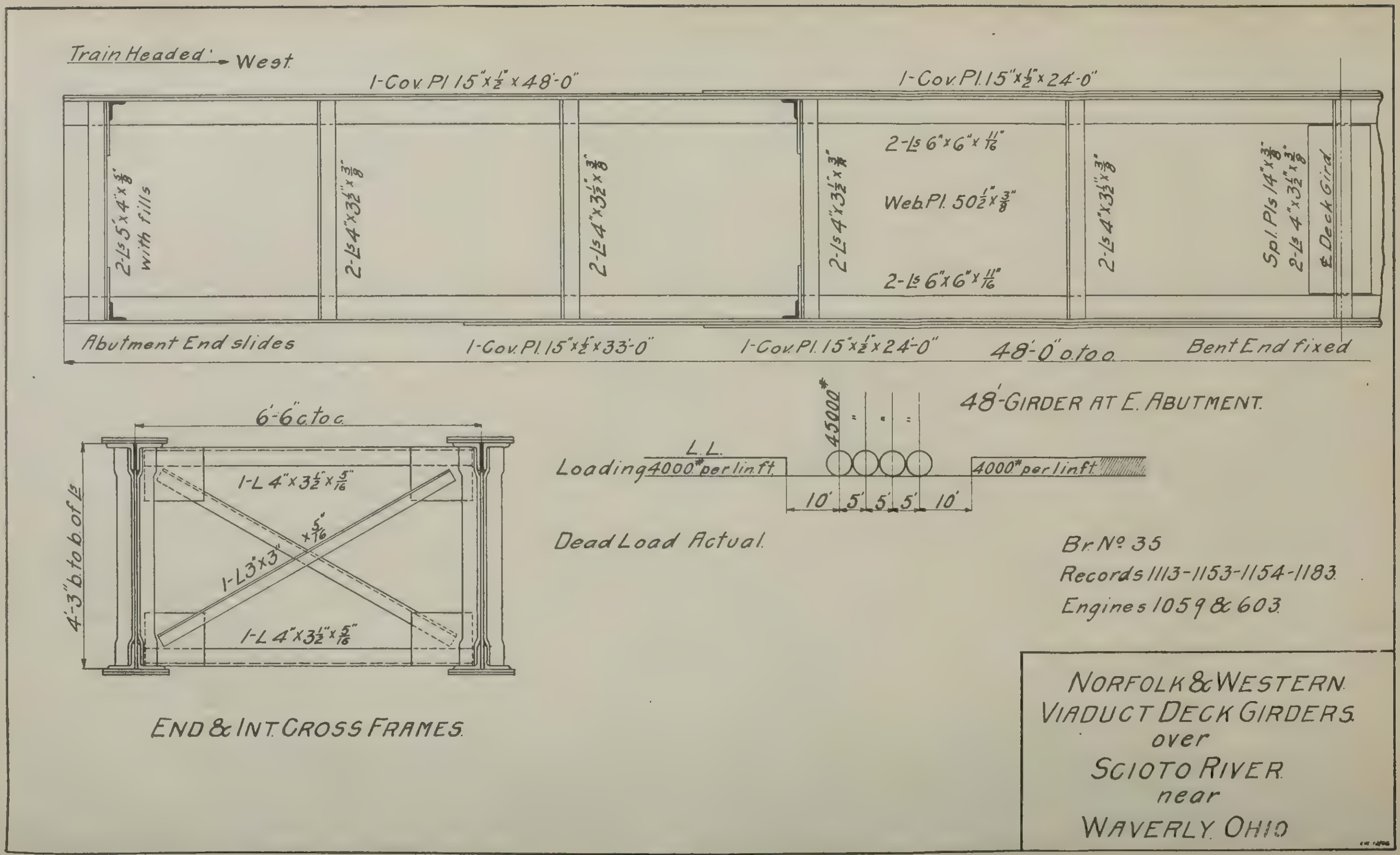

2Ls 6"x6"x3/4"
1Pl - 14"x 9/16" x 43'-0"
1Pl - 14" x 9/16" x 22'-0"
2Ls 5"x3" x 3/8"
2Ls 4"x3"x3/8"
do
do
do
Web 44"x 7/16" = 19.25 □"
do
do
do
do
2'-0"
3 @ 2'-2" = 6'-6"
4 @ 3'-3" = 13'-0"
43'-0" C to C
2Ls-6"x6" x 3/4"
1Pl-14"x 9/16" x 30'-0"
1Pl-14"x 9/16" x 22'-0"
℄
Base of Rail
6'-6" C to C
1L 4"x3"x3/8"
1L 3"x3"x3/8"
1L 4"x3"x3/8"
1L 3"x3"x3/8"
1L 4"x3"x3/8"
1L 3"x3"x3/8"
1L 4"x3"x3/8"
1L 3"x3"x3/8"
3'-4" B to B of Ls
4'-7"
1/2 End Frame
1/2 Interior Frame
LOADING
DEAD - 1080 # PER LINEAR FOOT.
LIVE - N & W SPEC. 1899
BRIDGE - # 33
RECORDS - 1080-1090 ; 1091-1112
ENGINES - 1059 - 594 - 1033
NORFOLK & WESTERN
DECK GIRDER
OVER
LITTLE SCIOTO RIVER
SCIOTOVILLE - OHIO

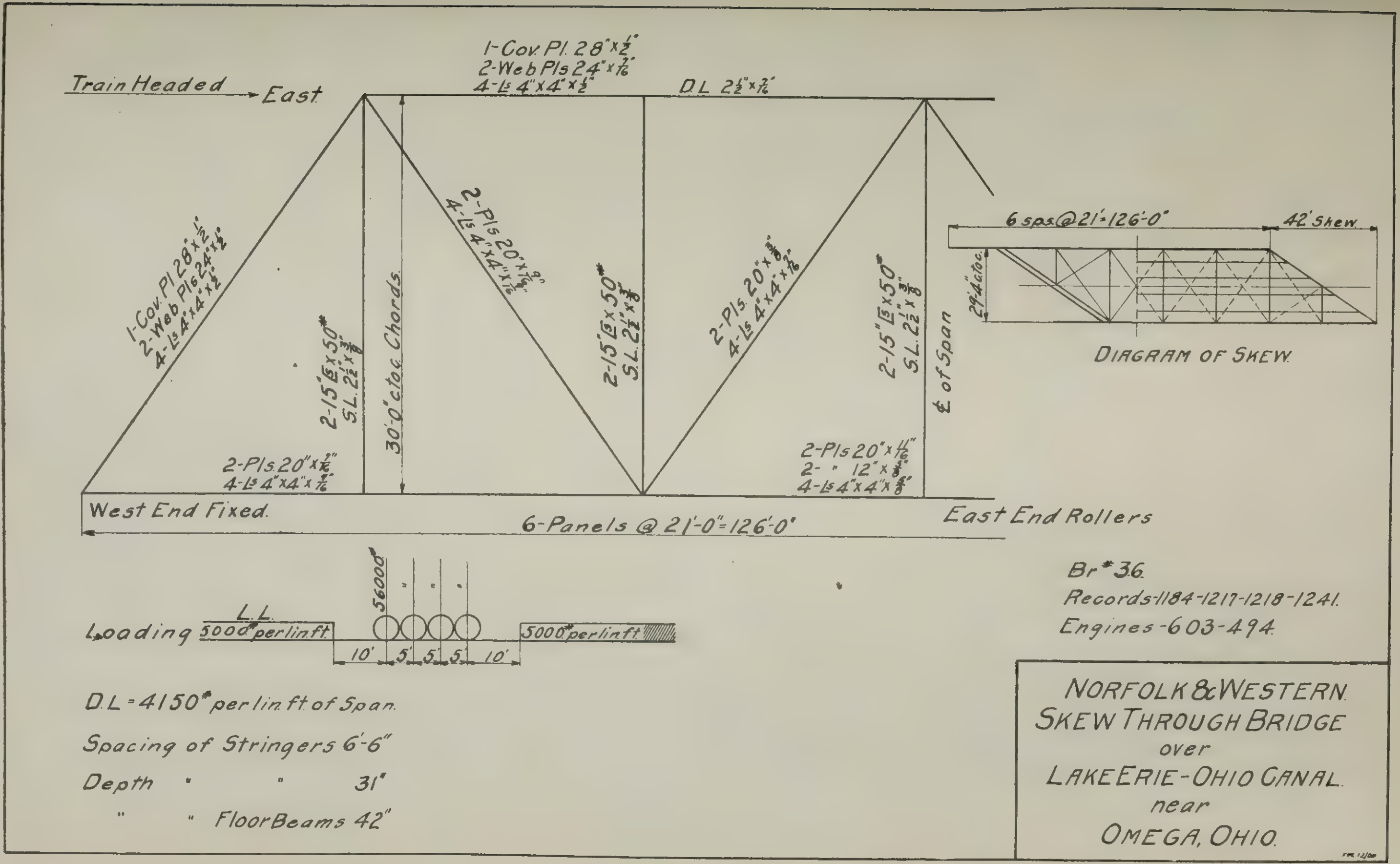


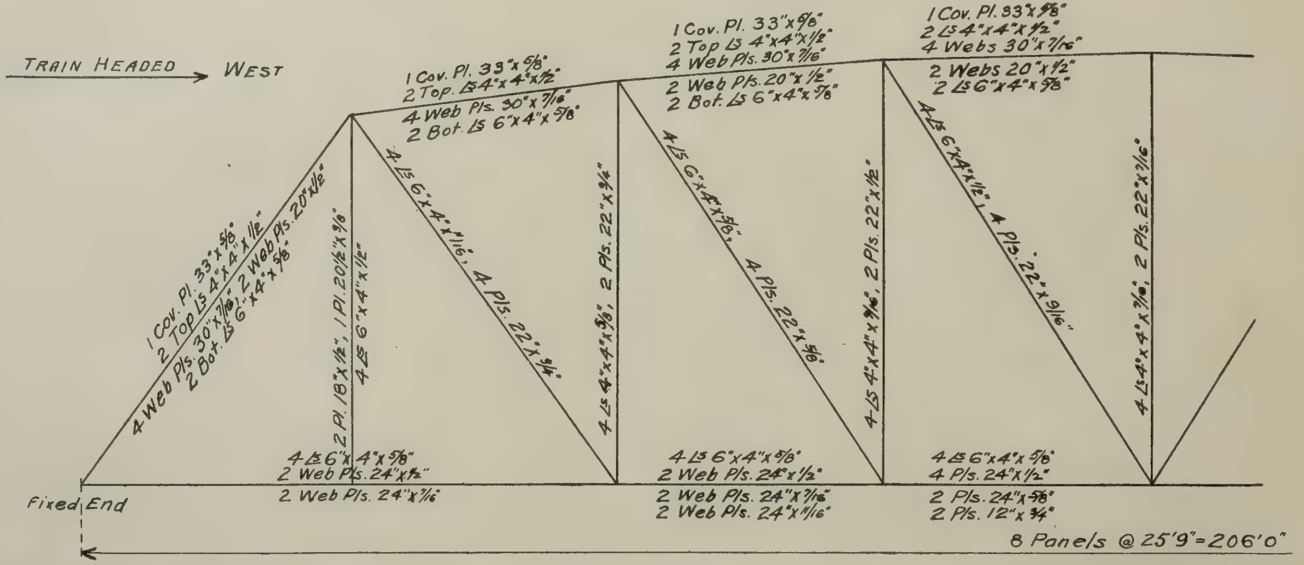
BRIDGE No. 34.
RECORDS 1113-1153, 1154-1183.
ENGINES # 1159, 603.

Loading :- Not known.
Spacing of Stringers
Depth of Stringers 30"
Depth of Floor Beams 42"

NORFOLK AND WESTERN RY.
THROUGH BRIDGE
OVER
SCIOTO RIVER
near
WAVERLY, OHIO.


Train Headed → West
1-Cov. Pl 15"x1/2"x48'-0"
1-Cov. Pl. 15"x1/2"x24'-0"
2-Ls 5"x4"x3/8" with fills
2-Ls 4"x3 1/2"x3/8"
2-Ls 4"x3 1/2"x3/8"
2-Ls 4"x3 1/2"x3/8"
2-Ls 6"x6"x11/16"
Web Pl. 50 1/2"x3/8"
2-Ls 6"x6"x11/16"
2-Ls 4"x3 1/2"x3/8"
Spl. Pls 14"x3/8"
2-Ls 4"x3 1/2"x3/8"
℄ Deck Gird.
Abutment End slides
1-Cov. Pl. 15"x1/2"x33'-0"
1-Cov. Pl. 15"x1/2"x24'-0"
48'-0" o. to o.
Bent End fixed
48'-Girder at E. Abutment.
L.L.
Loading 4000# per lin. ft.
45000#
4000# per lin. ft.
10' 5' 5' 5' 10'
Dead Load Actual.
Br. No. 35
Records 1113-1153-1154-1183
Engines 1059 & 603
6'-6" c. to c.
4'-3" b. to b. of Ls
1-L 4"x3 1/2"x5/16"
1-L 3"x3"x5/16"
1-L 4"x3 1/2"x5/16"
End & Int. Cross Frames.
Norfolk & Western
Viaduct Deck Girders
over
Scioto River
near
Waverly Ohio


Train Headed → East
1-Cov. Pl. 28"×½"
2-Web Pls 24"×7/16"
4-Ls 4"×4"×½"
D.L 2½"×7/16"
1-Cov. Pl. 28"×½"
2-Web Pls 24"×½"
4-Ls 4"×4"×½"
2-15"[s×50#
S.L. 2½"×3/8"
30'-0" c. to c. Chords.
2-Pls 20"×9/16"
4-Ls 4"×4"×7/16"
2-15"[s×50#
S.L. 2½"×3/8"
2-Pls. 20"×3/8"
4-Ls 4"×4"×7/16"
2-15"[s×50#
S.L. 2½"×3/8"
℄ of Span
2-Pls. 20"×7/16"
4-Ls 4"×4"×7/16"
2-Pls 20"×11/16"
2- " 12"×3/8"
4-Ls 4"×4"×5/8"
West End Fixed.
6-Panels @ 21'-0"=126'-0"
East End Rollers
6 sps. @ 21'=126'-0"
42' Skew.
29'-4" c. to c.
DIAGRAM OF SKEW.
56000#
L.L.
Loading 5000# per lin. ft.
5000# per lin. ft.
10'
5'
5'
5'
10'
D.L = 4150# per lin. ft. of Span.
Spacing of Stringers 6'-6"
Depth " " 31"
" " FloorBeams 42"
Br. #36.
Records-1184-1217-1218-1241.
Engines-603-494.
NORFOLK & WESTERN.
SKEW THROUGH BRIDGE
over
LAKE ERIE-OHIO CANAL.
near
OMEGA, OHIO.



Loading:- Spec. Penna. Lines, West-1897.

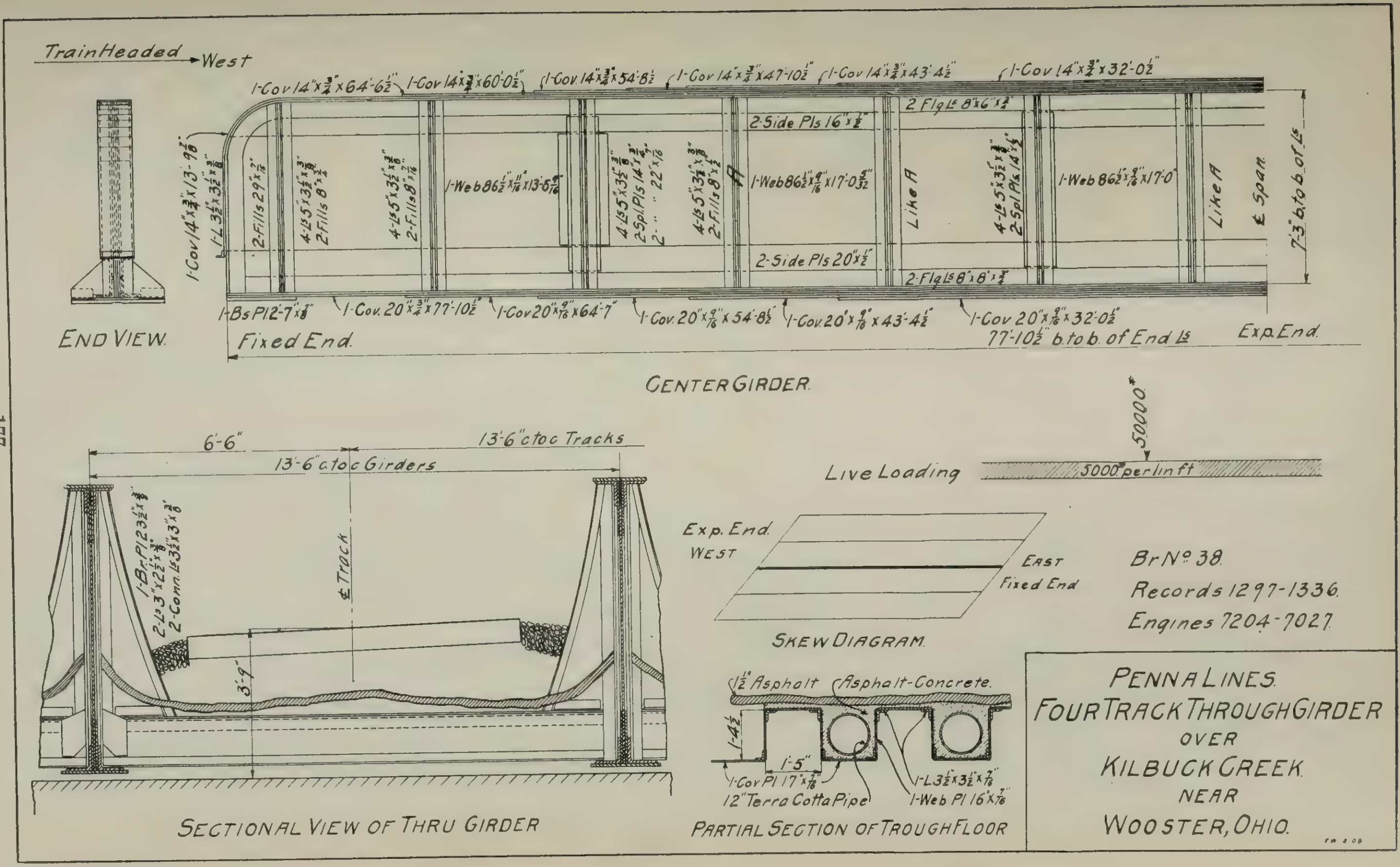
Spacing of Stringers 2'0" 3'0" 2'0"

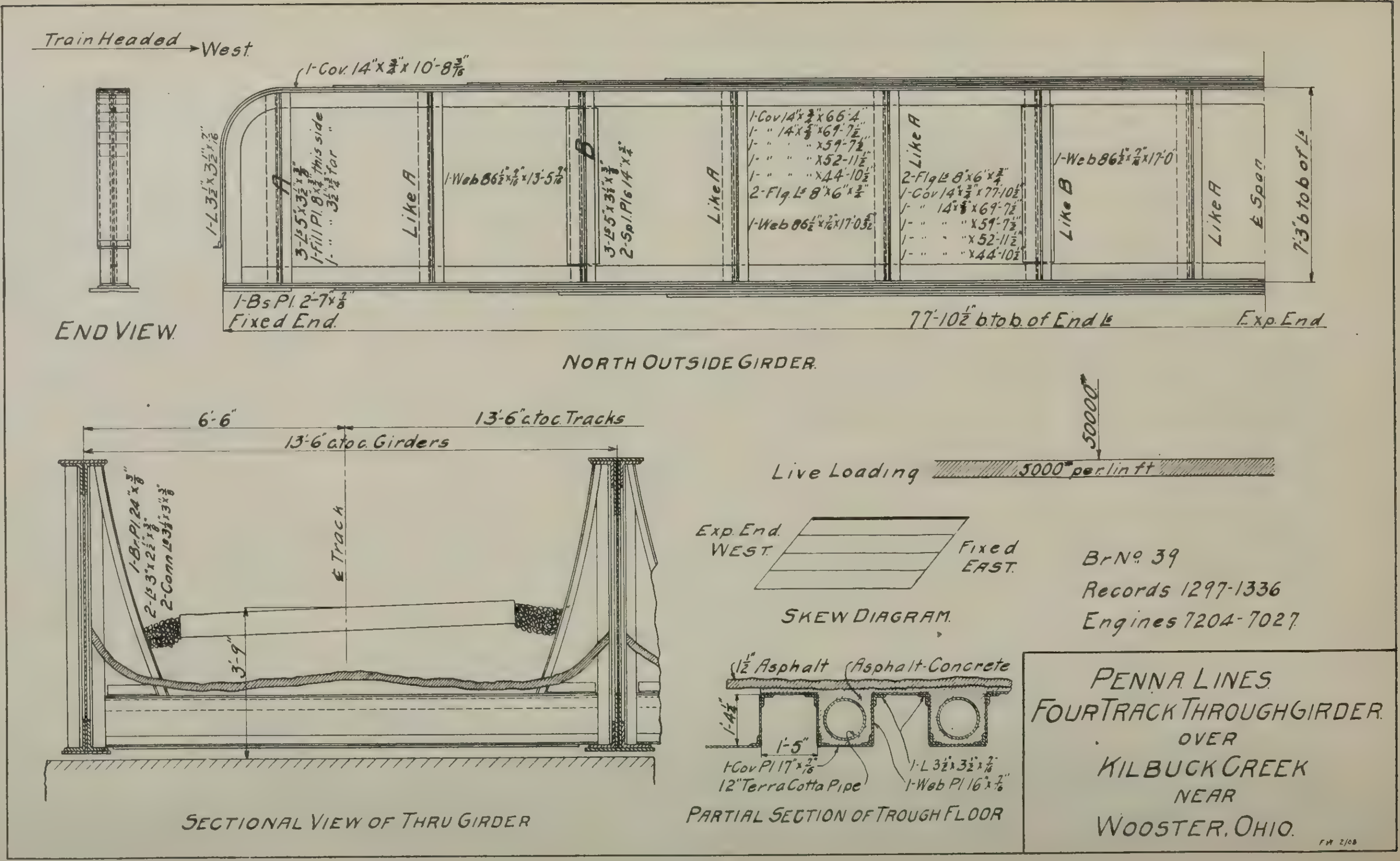
Depth of Stringers 3' 1 1/4" b to b. Ls

Depth of Floor Beams 5' 7 1/4" b. to b. Ls

BRIDGE No. 37.
RECORDS #1242-1268; 1269-1296
Engines #7204, 7027.

PENNA. LINES.
DOUBLE TRACK BRIDGE
OVER
MAHENING RIVER
at
NILES, OHIO


Train Headed → West
1-Cov 14"x3/4"x64'-6 1/2"
1-Cov 14"x3/4"x60'-0 1/2"
1-Cov. 14"x3/4"x54'-8 1/2
1-Cov 14"x3/4"x47'-10 1/2"
1-Cov 14"x3/4"x43'-4 1/2"
1-Cov 14"x3/4"x32'-0 1/2"
1-Cov 14"x3/4"x13'-9 1/8"
1-L 3 1/2"x3 1/2"x3/8"
2-Fills 29"x7/16"
4-Ls 5"x3 1/2"x3/8"
2-Fills 8"x1/4"
4-Ls 5"x3 1/2"x3/8"
2-Fills 8"x7/16"
1-Web 86 1/2"x11/16"x13'-5 9/16"
4-Ls 5"x3 1/2"x3/8"
2-Spl Pls 14"x1/4"
2- " " 22"x7/16
4-Ls 5"x3 1/2"x3/8"
2-Fills 8"x1/2
A
2-Side Pls 16"x1/2"
1-Web 86 1/2"x9/16"x17'-0 5/32"
2-Side Pls 20"x1/2"
Like A
2 Flg Ls 8"x6"x3/4"
4-Ls 5"x3 1/2"x3/8"
2-Spl Pls 14"x1/2"
2-Flg Ls 8"x8"x3/4"
1-Web 86 1/2"x9/16"x17'-0"
Like A
℄ Span
7'-3" b. to b. of Ls
1-Bs Pl 2'-7"x7/8"
1-Cov. 20"x3/4"x77'-10 1/2"
1-Cov 20"x9/16"x64'-7"
1-Cov. 20"x9/16"x54'-8 1/2"
1-Cov. 20"x9/16"x43'-4 1/2"
1-Cov 20"x9/16"x32'-0 1/2"
Fixed End.
77'-10 1/2" b. to b. of End Ls
Exp. End.
End View.
Center Girder.
50000#
Live Loading
5000# per lin ft
6'-6"
13'-6" c to c Tracks
13'-6" c to c Girders
1-Br. Pl 23 1/2"x3/8"
2-Ls 3"x2 1/2"x3/8"
2-Conn. Ls 3 1/2"x3"x3/8"
℄ Track
3'-9"
Sectional View of Thru Girder
Exp. End.
West
East
Fixed End
Skew Diagram.
Br. No. 38.
Records 1297-1336.
Engines 7204-7027.
1 1/2" Asphalt
Asphalt-Concrete.
1'-4 1/2"
1'-5"
1-Cov Pl 17"x7/16"
12" Terra Cotta Pipe
1-L 3 1/2"x3 1/2"x7/16"
1-Web Pl 16"x7/16"
Partial Section of Trough Floor
Penna Lines.
Four Track Through Girder
over
Kilbuck Creek.
near
Wooster, Ohio.


END VIEW.

NORTH OUTSIDE GIRDER.

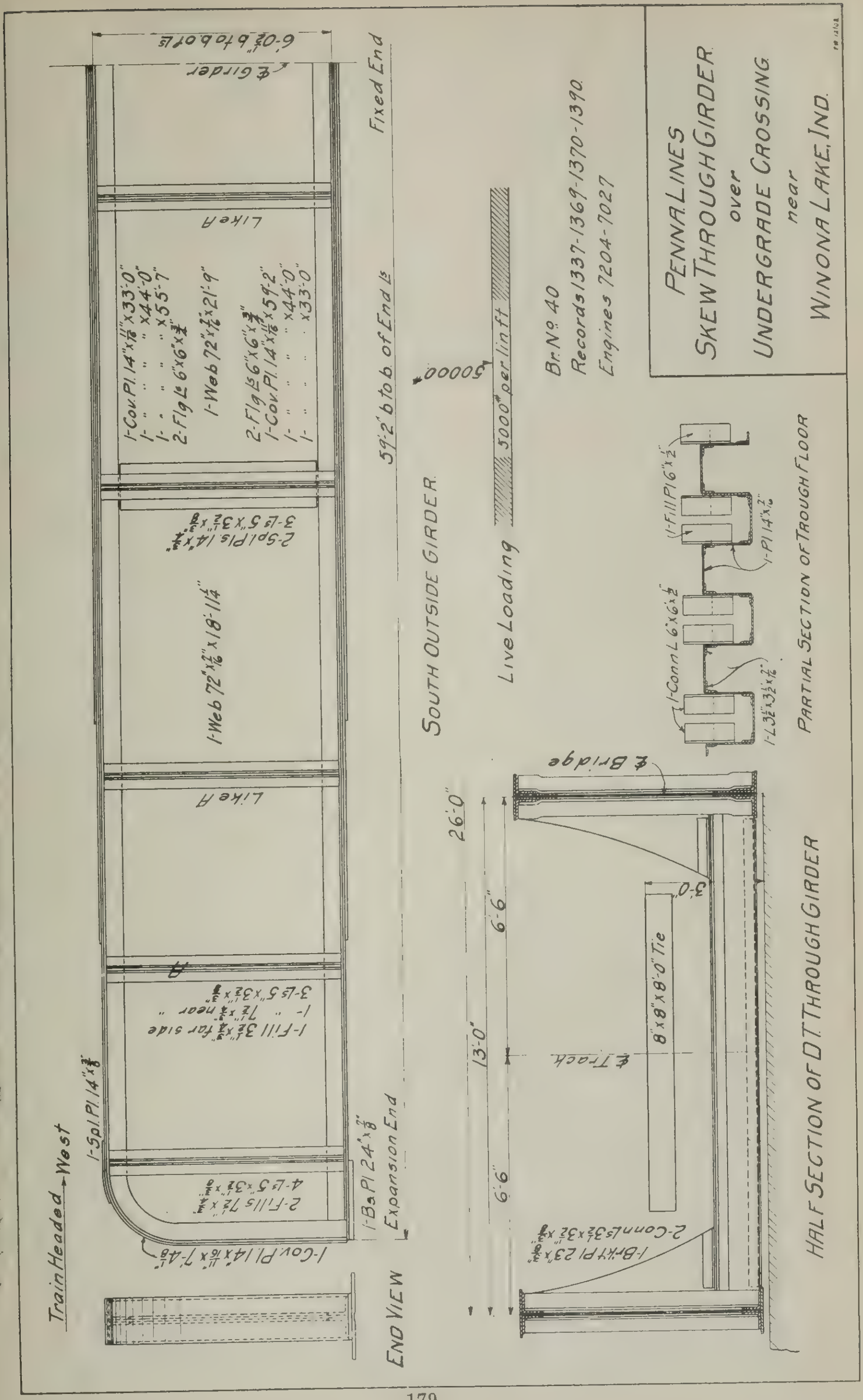
SECTIONAL VIEW OF THRU GIRDER

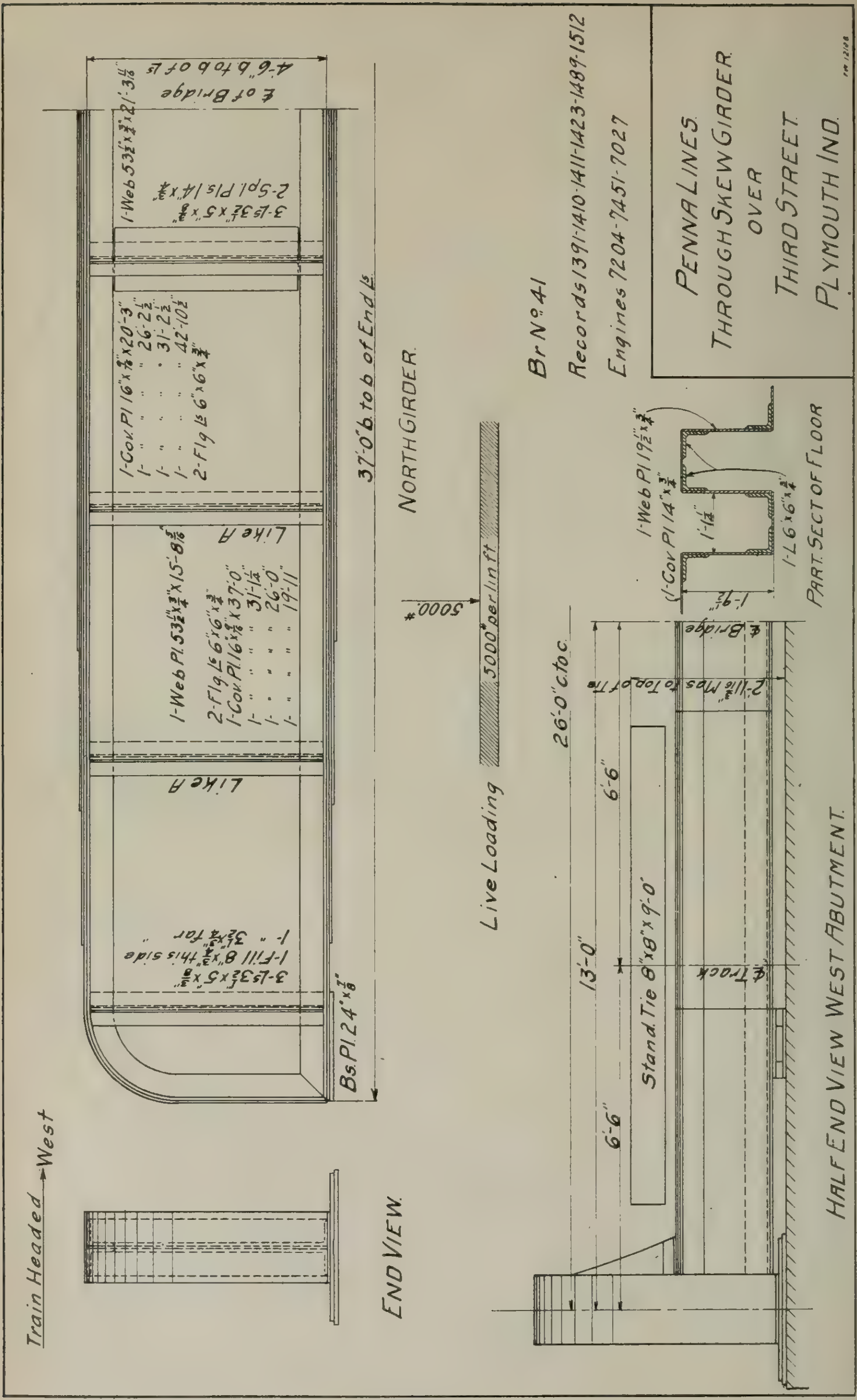
SKEW DIAGRAM.

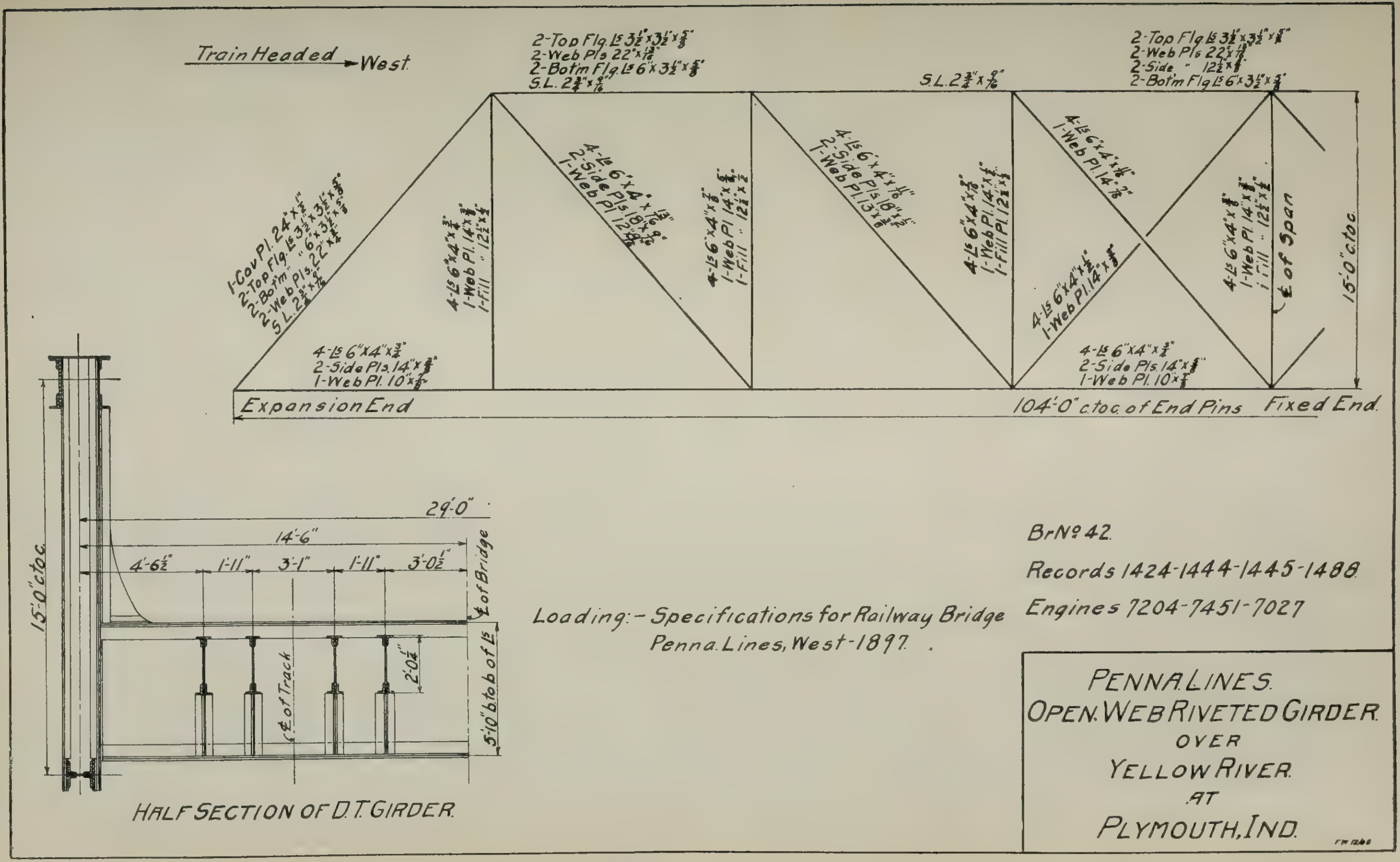
PARTIAL SECTION OF TROUGH FLOOR

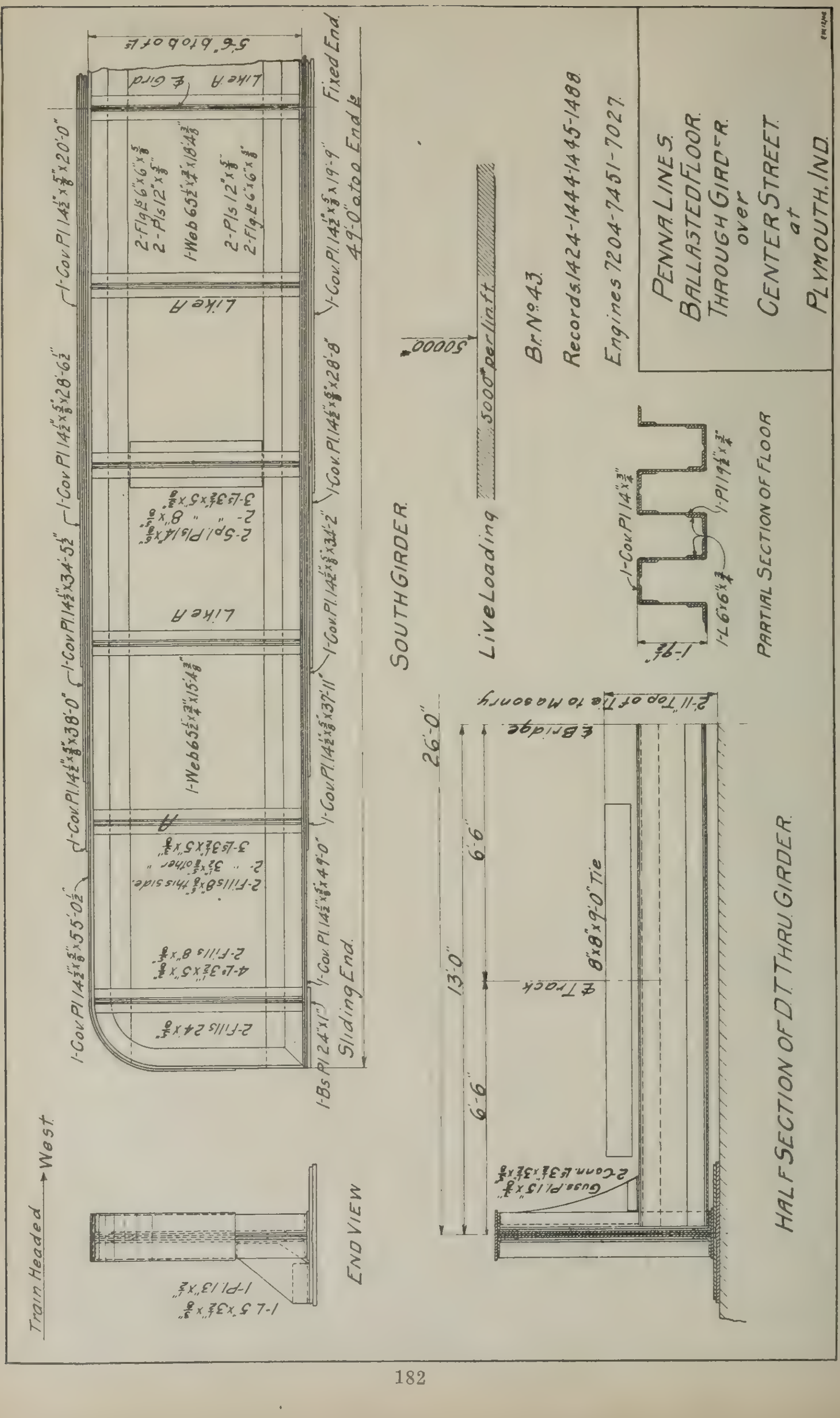
PENNA. LINES
FOUR TRACK THROUGH GIRDER
OVER
KILBUCK CREEK
NEAR
WOOSTER, OHIO.

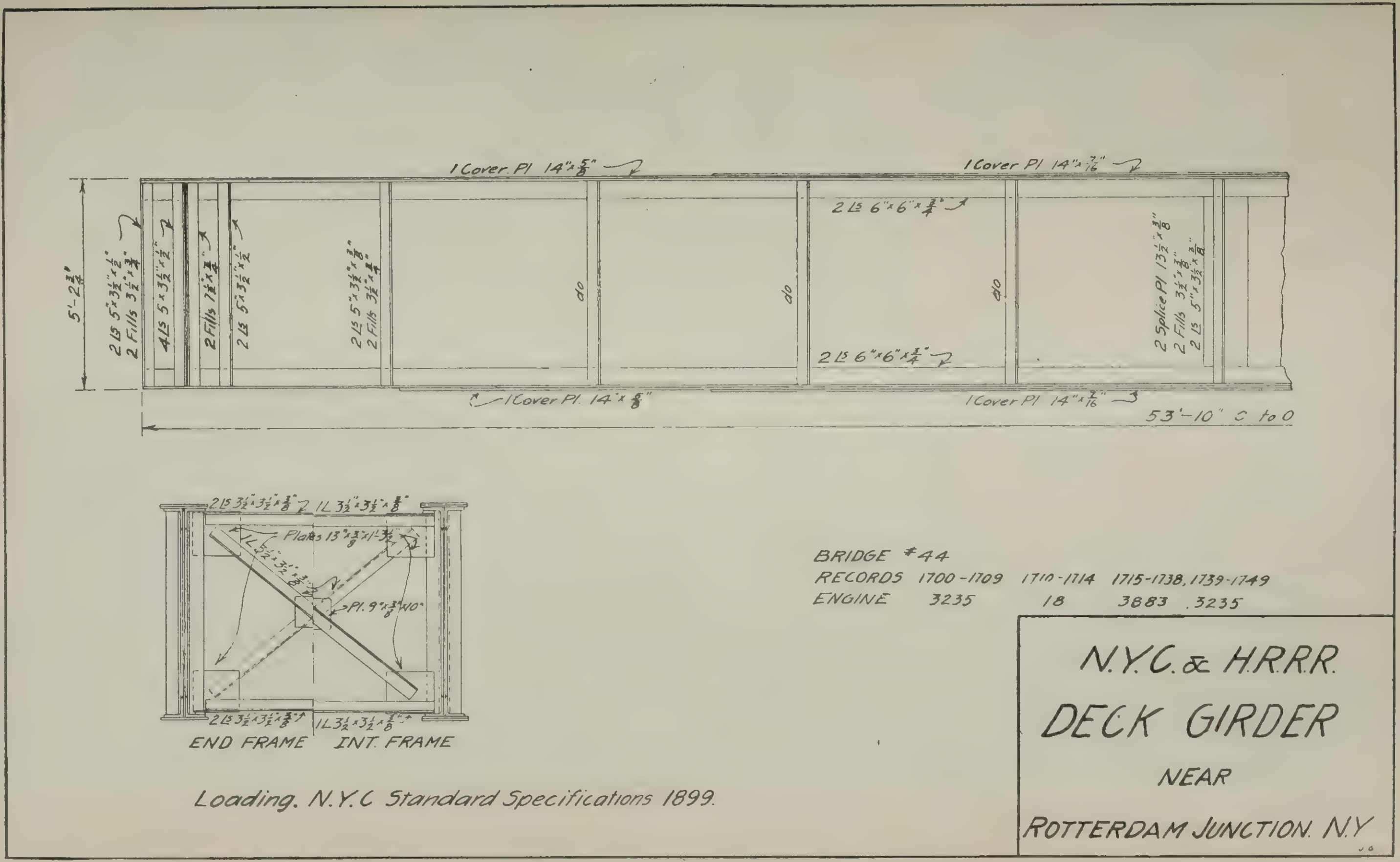
PLATE I—am.

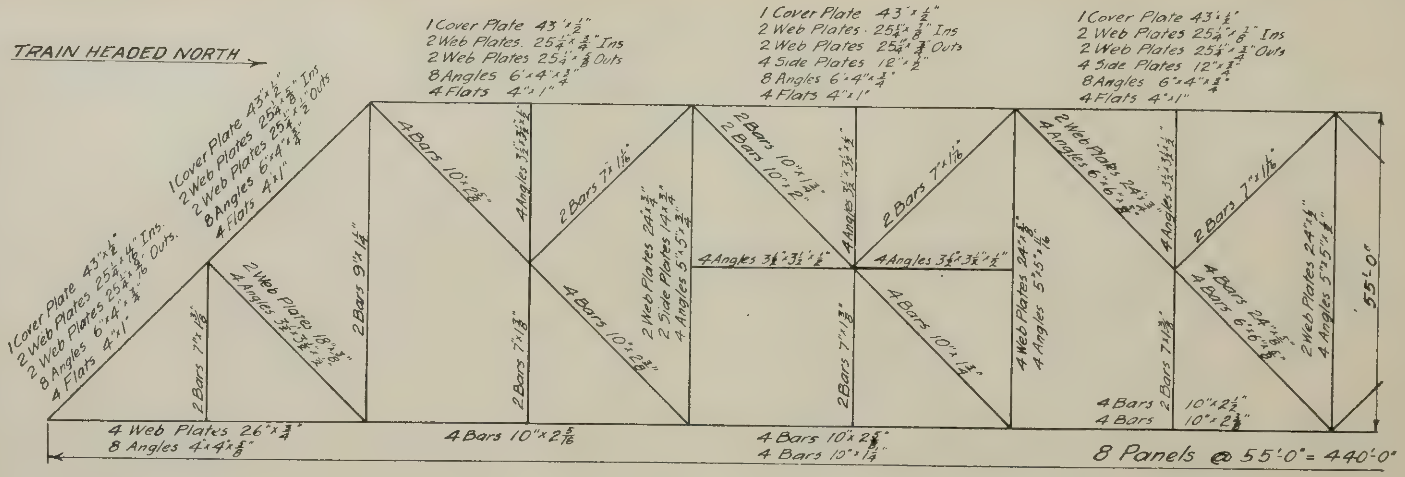

PENNA. LINES
SKEW THROUGH GIRDER
over
UNDERGRADE CROSSING
near
WINONA LAKE, IND.
Br. No. 40
Records 1337-1369-1370-1390
Engines 7204-7027
Live Loading
5000# per lin ft
50000#
SOUTH OUTSIDE GIRDER
Train Headed → West
Fixed End
Expansion End
6'-0¾" b to b of Ls
℄ Girder
59'-2" b to b of End Ls
Like A
Like A
A
1-Cov. Pl. 14"x11/16"x33'-0"
1- " " " x44'-0"
1- " " " x55'-7"
2-Flg Ls 6"x6"x¾"
1-Web 72"x7/16"x21'-9"
2-Flg Ls 6"x6"x¾"
1-Cov. Pl. 14"x11/16"x59'-2"
1- " " " x44'-0"
1- " " " x33'-0"
3-Ls 5"x3½"x⅜"
2-Spl. Pls. 14"x⅜"
1-Web 72"x7/16"x18'-1¼"
3-Ls 5"x3½"x⅜"
1- " 7½"x⅜" near "
1-Fill 3½"x⅜" far side
1-Spl. Pl. 14"x⅜"
2-Fills 7½"x⅜"
4-Ls 5"x3½"x⅜"
1-Bs. Pl. 24"x⅞"
1-Cov. Pl. 14"x11/16"x7'-4⅛"
END VIEW
26'-0"
13'-0"
6'-6"
6'-6"
3'-0"
℄ Bridge
℄ Track
8"x8"x8'-0" Tie
2-Conn Ls 3½"x3½"x⅜"
1-Bkt Pl 23"x⅜"
HALF SECTION OF D.T. THROUGH GIRDER
1-Fill Pl 6"x½"
1-Pl 14"x½"
1-Conn L 6"x6"x½"
1-L 3½"x3½"x½"
PARTIAL SECTION OF TROUGH FLOOR


PENNA LINES
THROUGH SKEW GIRDER
OVER
THIRD STREET
PLYMOUTH IND.
Br. No. 41
Records 1391·1410·1411·1423·1489·1512
Engines 7204·7451·7027
NORTH GIRDER
37'-0" b. to b. of End Ls
4'-6" b. to b. of Ls
℄ of Bridge
1-Web 53½"x⅜" x 21'-3⅛"
3-Ls 3½"x5"x⅜"
2-Spl. Pls. 14"x⅜"
1-Cov. Pl. 16"x⅞"x20'-3"
1- " " 26'-2½"
1- " " 31'-2½"
1- " " 42'-10½"
2-Flg. Ls 6"x6"x¾"
Like A
1-Web Pl. 53½"x¾" x 15'-8⅝"
2-Flg. Ls 6"x6"x¾"
1-Cov. Pl. 16"x⅞"x37'-0"
1- " 31'-1¼"
1- " 26'-0"
1- " 19'-11"
Like A
3-Ls 3½"x5"x⅜"
1-Fill 8"x¾" this side
1- " 3½"x¾" far "
Bs. Pl. 24"x⅞"
Train Headed → West
END VIEW.
5000#
5000# per lin. ft.
Live Loading
26'-0" c. to c.
13'-0"
6'-6"
6'-6"
Stand. Tie 8"x8"x9'-0"
2'-11⅛" Mas. to Top of Tie
℄ Bridge
℄ Track
HALF END VIEW WEST ABUTMENT.
1-Cov. Pl. 14"x¾"
1-Web Pl. 19½"x¾"
1'-1¼"
1'-9½"
1-L 6"x6"x¾"
PART. SECT. OF FLOOR


Train Headed → West.
2-Top Flg. Ls 3½"×3½"×⅝"
2-Web Pls 22"×13/16"
2-Botm Flg. Ls 6"×3½"×⅝"
S.L. 2¾"×9/16"
1-Cov Pl. 24"×½"
2-Top Flg. Ls 3½"×3½"×⅝"
2-Botm " 6"×3½"×⅝"
2-Web Pls. 22"×¾"
S.L. 2¾"×9/16"
4-Ls 6"×4"×¾"
2-Side Pls. 14"×⅜"
1-Web Pl. 10"×⅝"
4-Ls 6"×4"×¾"
1-Web Pl. 14"×⅜"
1-Fill " 12½"×½"
4-Ls 6"×4"×13/16"
2-Side Pls. 18"×9/16"
1-Web Pl. 12"×9/16"
4-Ls 6"×4"×⅞"
1-Web Pl 14"×⅝"
1-Fill " 12½"×½"
S.L. 2¾"×9/16"
4-Ls 6"×4"×11/16"
2-Side Pls 18"×½"
1-Web Pl. 13"×⅜"
4-Ls 6"×4"×7/16"
1-Web Pl. 14"×⅜"
1-Fill Pl. 12½"×⅜"
2-Top Flg Ls 3½"×3½"×⅝"
2-Web Pls 22"×13/16"
2-Side " 12½"×⅝"
2-Botm Flg Ls 6"×3½"×⅝"
4-Ls 6"×4"×11/16"
1-Web Pl. 14"×7/16"
4-Ls 6"×4"×½"
1-Web Pl. 14"×⅝"
4-Ls 6"×4"×⅜"
1-Web Pl. 14"×⅜"
1-Fill " 12½"×⅜"
℄ of Span
15'-0" c. to c.
4-Ls 6"×4"×¾"
2-Side Pls. 14"×⅜"
1-Web Pl. 10"×⅝"
Expansion End
104'-0" c. to c. of End Pins
Fixed End.
15'-0" c. to c.
29'-0"
14'-6"
4'-6½"
1'-11"
3'-1"
1'-11"
3'-0½"
℄ of Bridge
2'-0¼"
℄ of Track
5'-10" b. to b. of Ls
HALF SECTION OF D.T. GIRDER.
Loading:—Specifications for Railway Bridge
Penna. Lines, West-1897.
Br. No. 42.
Records 1424-1444-1445-1488
Engines 7204-7451-7027
PENNA. LINES.
OPEN. WEB RIVETED GIRDER
OVER
YELLOW RIVER
AT
PLYMOUTH, IND.


PENNA LINES
BALLASTED FLOOR
THROUGH GIRDER
over
CENTER STREET
at
PLYMOUTH, IND.
Br. No. 43
Records 1424-1444-1445-1488
Engines 7204-7451-7027
SOUTH GIRDER
Live Loading
50000
5000# per lin ft
PARTIAL SECTION OF FLOOR
1-Cov Pl 14"x3/4"
1-Pl 19 1/2"x3/4"
1-L 6"x6"x3/4"
HALF SECTION OF D.T. THRU GIRDER
2'-11" Top of Tie to Masonry
℄ Bridge
℄ Track
8"x8"x9'-0" Tie
26'-0"
13'-0"
6'-6"
6'-6"
Guss. Pl. 15"x3/8"
2 Conn. Ls 3 1/2"x3 1/2"x3/8"
END VIEW
1-Pl 13"x3/4"
1-L 5"x3 1/2"x5/8"
Train Headed → West
Sliding End
Fixed End
49'-0" c to c End Bs
5'-6" b to b of Ls
1-Bs Pl 24"x1"
2-Fills 24"x3/4"
4-Ls 3 1/2"x5"x3/8"
2-Fills 8"x3/8"
2-Fills 8"x3/8" this side
2- " 3 1/2"x3/8" other "
3-Ls 3 1/2"x5"x3/8"
A
1-Web 65 1/2"x3/4"x15'-4 3/8"
Like A
2-Spl Pls 14"x5/8"
2- " " 8"x5/8"
3-Ls 3 1/2"x5"x3/8"
Like A
2-Flg Ls 6"x6"x5/8"
2-Pls 12"x5/8"
1-Web 65 1/2"x3/4"x18'-4 3/8"
2-Pls 12"x5/8"
2-Flg Ls 6"x6"x5/8"
Like A
℄ Gird
1-Cov Pl 14 1/2"x5/8"x55'-0 1/2"
1-Cov Pl 14 1/2"x5/8"x38'-0"
1-Cov Pl 14 1/2"x34'-5 1/2"
1-Cov Pl 14 1/2"x5/8"x28'-6 1/2"
1-Cov Pl 14 1/2"x5/8"x20'-0"
1-Cov Pl 14 1/2"x5/8"x49'-0"
1-Cov Pl 14 1/2"x5/8"x37'-11"
1-Cov Pl 14 1/2"x5/8"x34'-2"
1-Cov Pl 14 1/2"x5/8"x28'-8"
1-Cov Pl 14 1/2"x5/8"x19'-9"


1 Cover. Pl 14"×5/8"
1 Cover Pl 14"×7/16"
5'-2 3/4"
2 Ls 5"×3 1/2"×1/2"
2 Fills 3 1/2"×3/4"
4 Ls 5×3 1/2"×1/2"
2 Fills 7 1/2"×3/4"
2 Ls 5"×3 1/2"×1/2"
2 Ls 5"×3 1/2"×3/8"
2 Fills 3 1/2"×3/4"
do
do
do
2 Ls 6"×6"×3/4"
2 Ls 6"×6"×3/4"
2 Splice Pl 13 1/2"×3/8"
2 Fills 3 1/2"×3/8"
2 Ls 5"×3 1/2"×3/8"
1 Cover Pl. 14"×5/8"
1 Cover Pl 14"×7/16"
53'-10" c to c
2 Ls 3 1/2"×3 1/2"×3/8"
1 L 3 1/2"×3 1/2"×3/8"
Plates 13"×3/8"×1'-3 1/2"
1 L 3 1/2"×3 1/2"×3/8"
Pl. 9"×3/8"×10"
2 Ls 3 1/2"×3 1/2"×3/8"
1 L 3 1/2"×3 1/2"×3/8"
END FRAME
INT. FRAME
Loading. N.Y.C Standard Specifications 1899.
BRIDGE #44
RECORDS 1700-1709 1710-1714 1715-1738, 1739-1749
ENGINE 3235 18 3883 3235
N.Y.C. & H.R.R.R.
DECK GIRDER
NEAR
ROTTERDAM JUNCTION. N.Y.



Loading - Live Load 3000 lbs. per Ft. of Track.

- Dead Load 3500 lbs. per Ft. of Track.

Spacing of Stringers 6'-0"

Depth of Stringers $39\frac{1}{2}$"

Depth of Floor Beams 60"

BRIDGE # 45.
RECORDS 1801-1835.
ENGINE 2543

C. B. & Q. R. R. BRIDGE
OVER
MISSOURI RIVER
NEAR
BELLEFONTAINE. MO.

PLATE II—a.

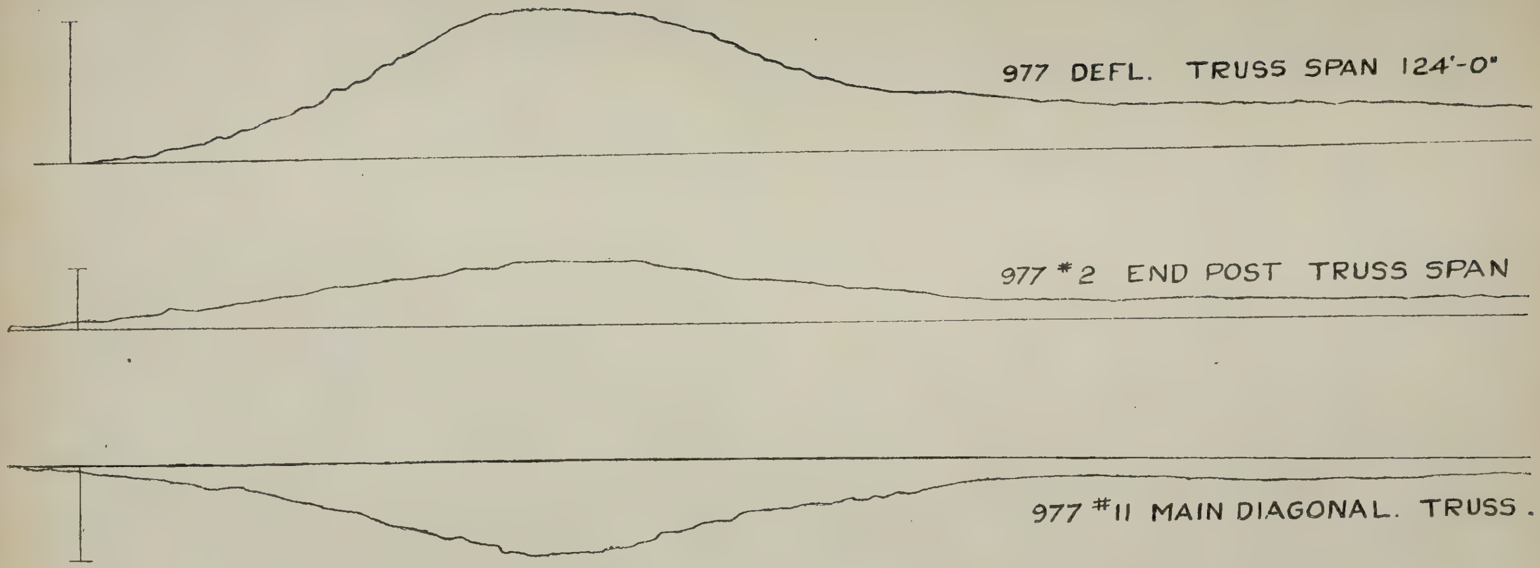
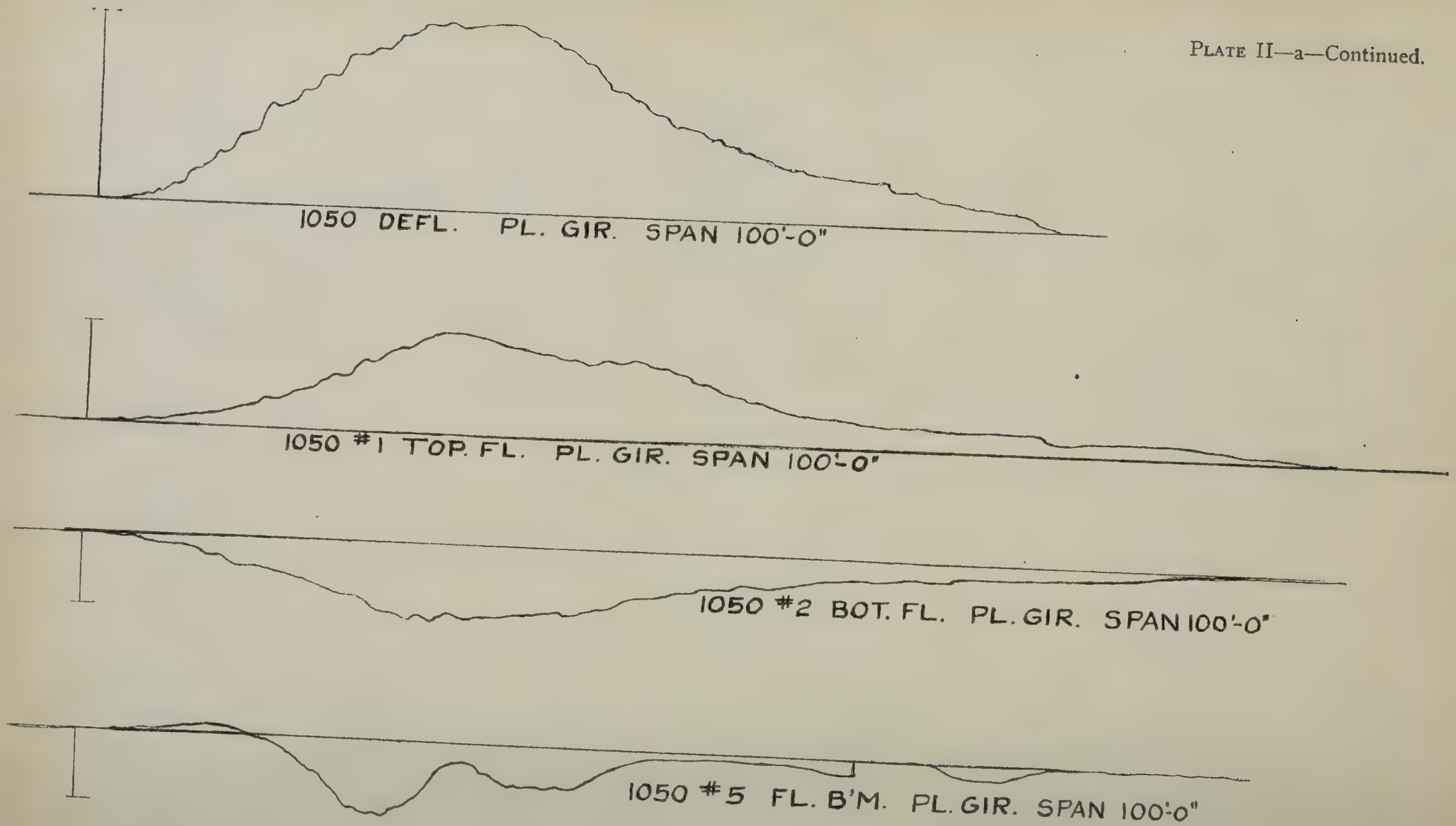
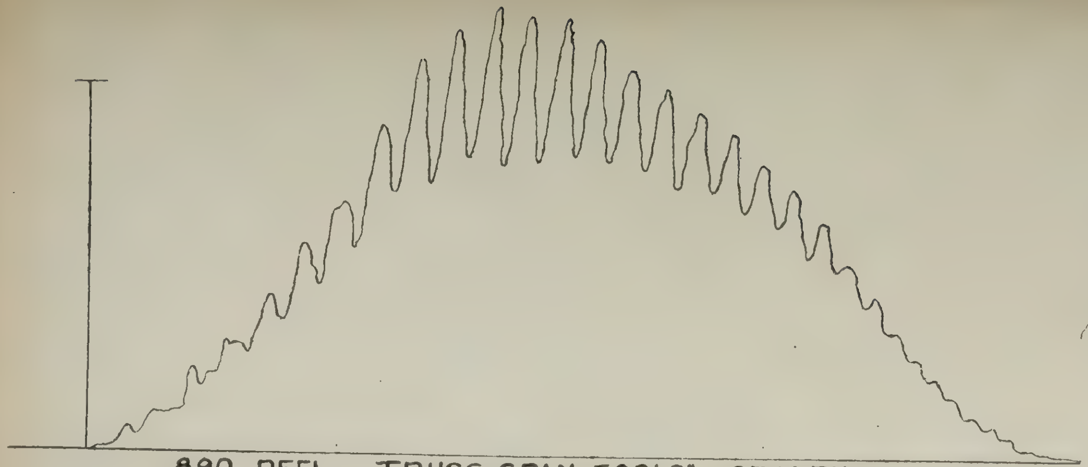
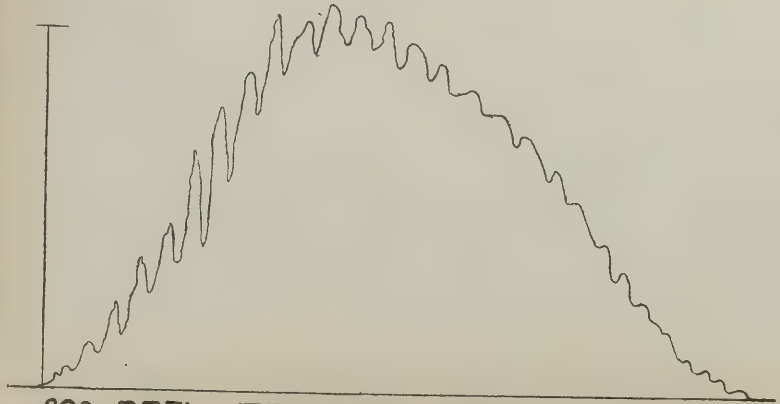

977 DEFL. TRUSS SPAN 124'-0"
977 *2 END POST TRUSS SPAN
977 #11 MAIN DIAGONAL. TRUSS.

Plate II—a—Continued.

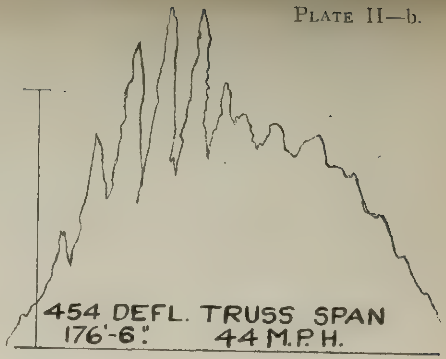




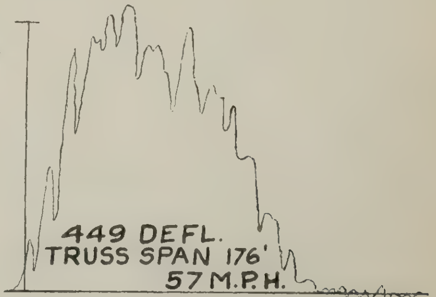
890 DEFL: TRUSS SPAN 300'-0". 25 M.P.H.



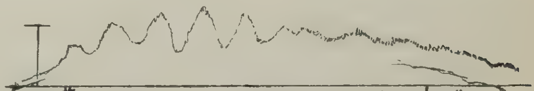
892 DEFL. TRUSS SPAN 300'-0" 31 M.P.H.



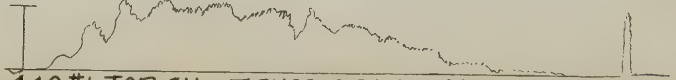
454 DEFL. TRUSS SPAN 176'-6". 44 M.P.H.



449 DEFL. TRUSS SPAN 176' 57 M.P.H.



454 #1 TOP CH TRUSS SPAN 176'-6" 44 M.P.H.



449 #1 TOP CH. TRUSS SPAN 176'-6 57 M.P.H

PLATE II—b—Continued.

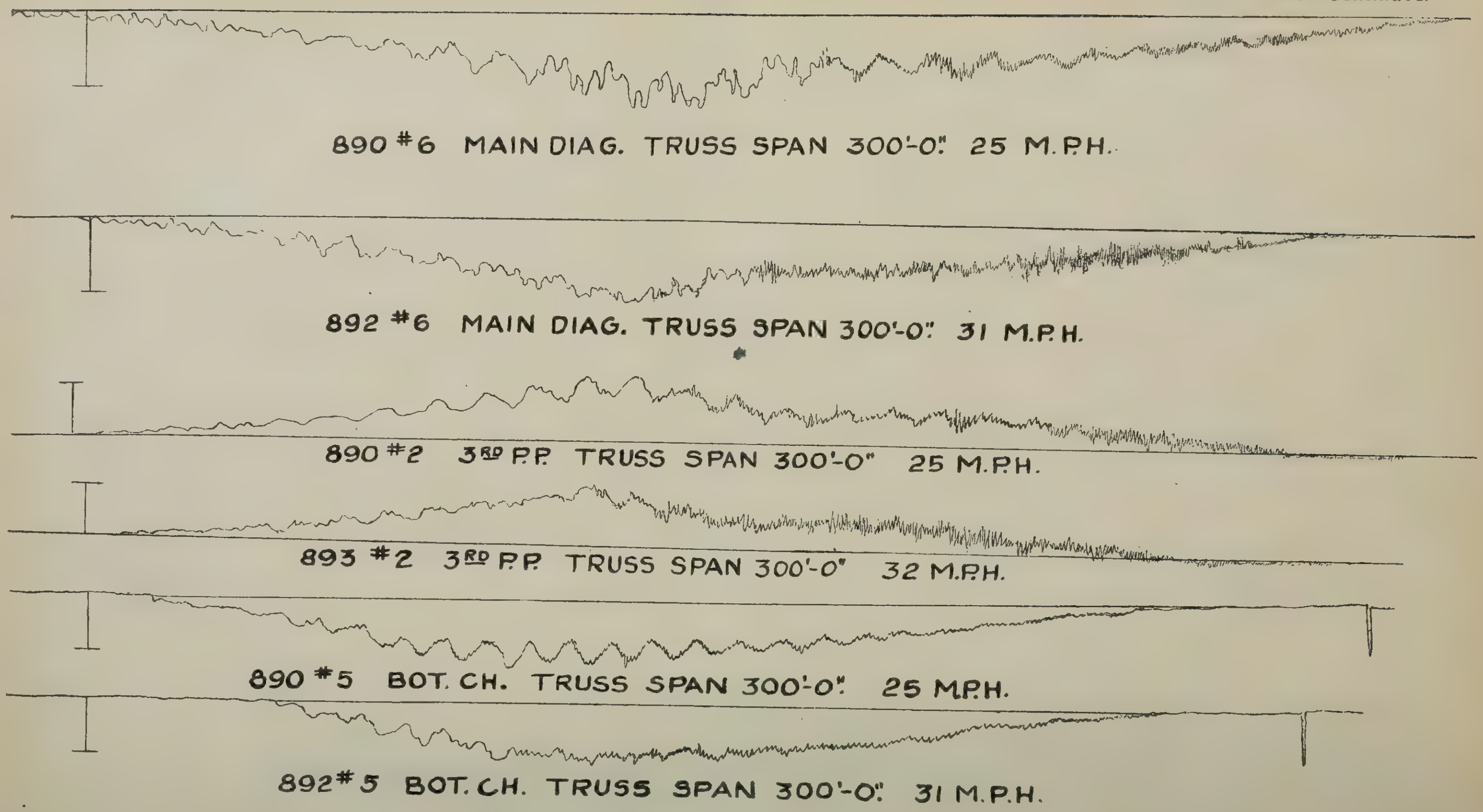


PLATE II—c.

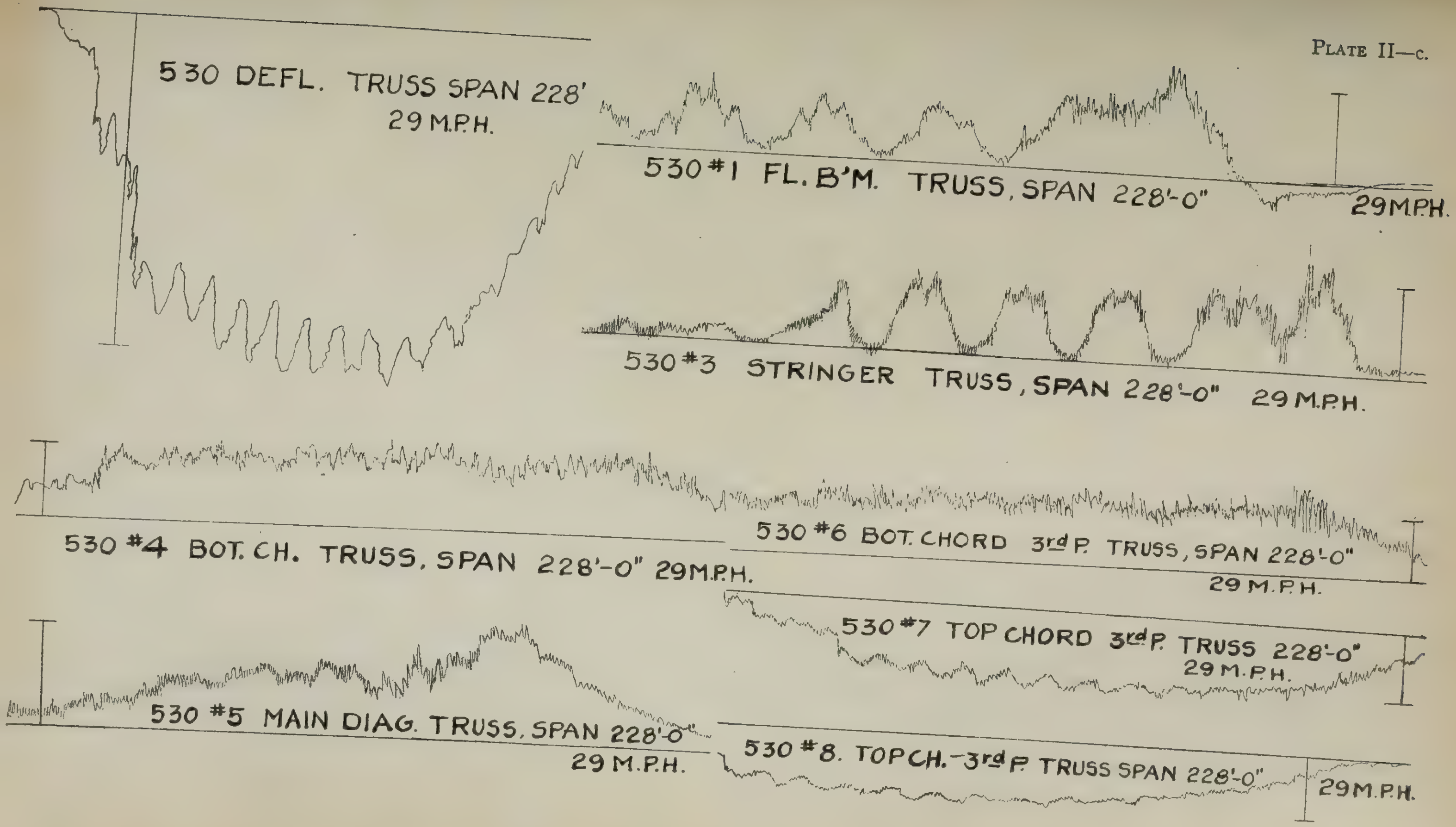

530 DEFL. TRUSS SPAN 228'
29 M.P.H.
530 #1 FL. B'M. TRUSS, SPAN 228'-0"
29 M.P.H.
530 #3 STRINGER TRUSS, SPAN 228'-0" 29 M.P.H.
530 #4 BOT. CH. TRUSS, SPAN 228'-0" 29 M.P.H.
530 #6 BOT. CHORD 3rd P. TRUSS, SPAN 228'-0"
29 M.P.H.
530 #7 TOP CHORD 3rd P. TRUSS 228'-0"
29 M.P.H.
530 #5 MAIN DIAG. TRUSS, SPAN 228'-0"
29 M.P.H.
530 #8. TOP CH.-3rd P. TRUSS SPAN 228'-0"
29 M.P.H.

Plate II—c—Continued.

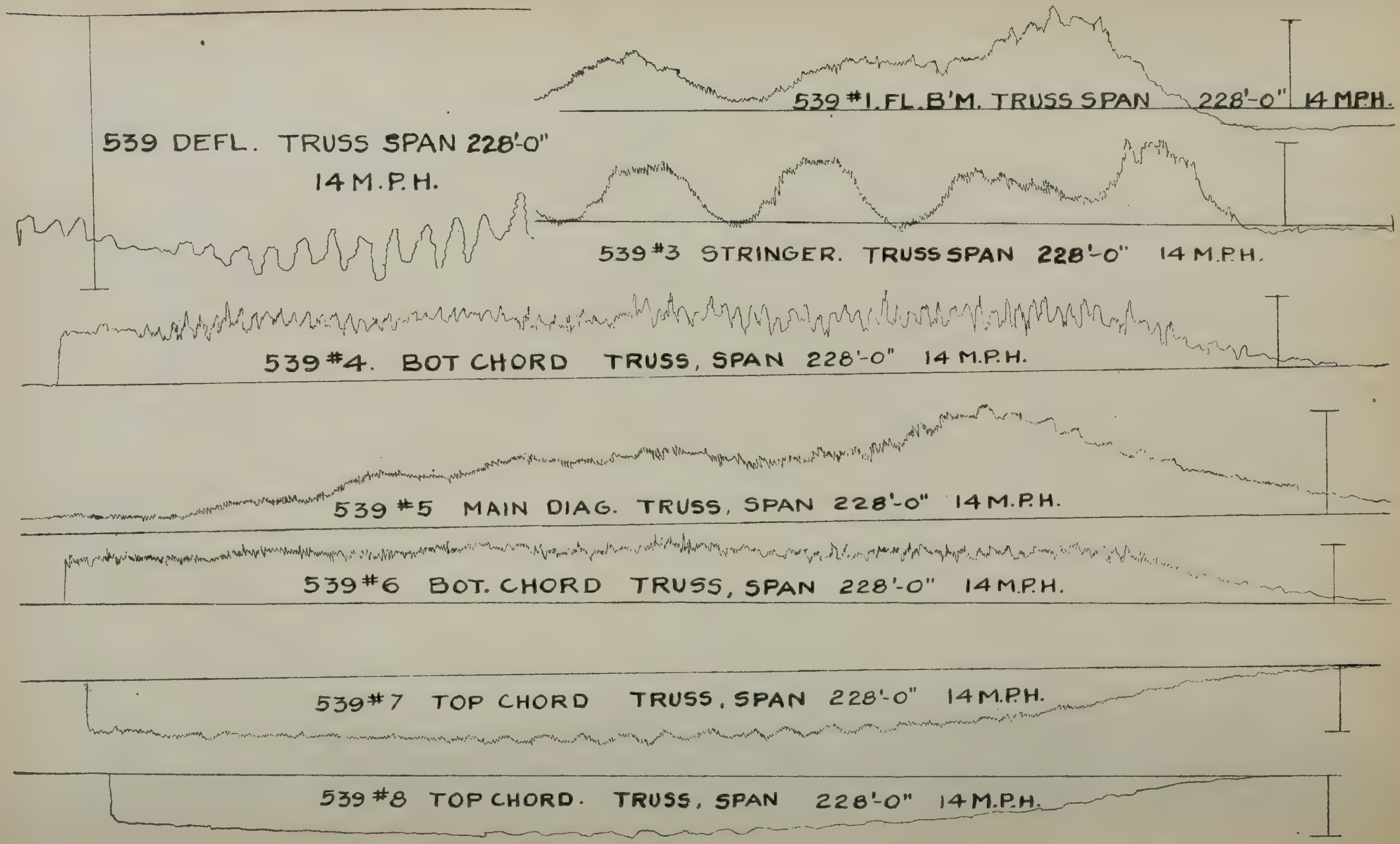
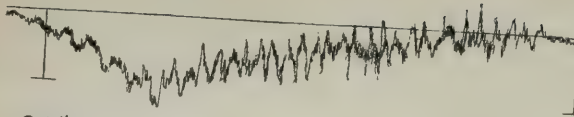
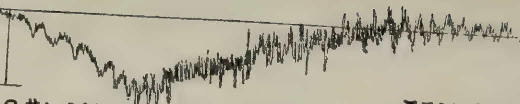


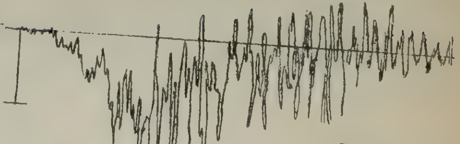
PLATE II—a.



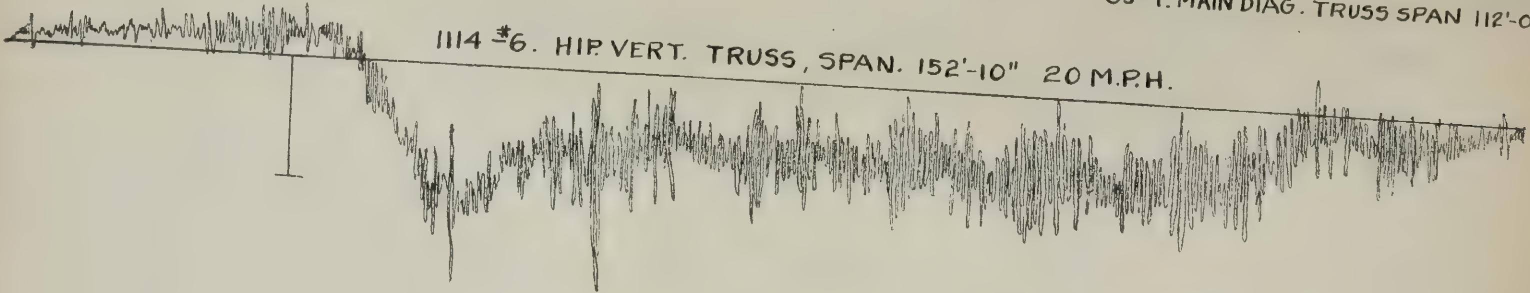
88#1, MAIN DIAG. TRUSS, SPAN 112'-0"
27 M.P.H.



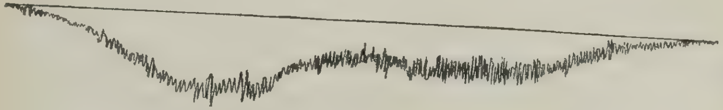
78#1 MAIN DIAG. TRUSS SPAN 112'-0"
33 M.P.H.



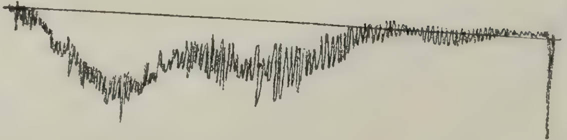
83#1. MAIN DIAG. TRUSS SPAN 112'-0"
51 M.P.H.



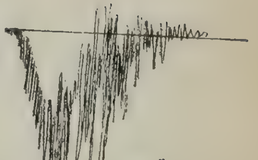
1114 #6. HIP. VERT. TRUSS, SPAN. 152'-10" 20 M.P.H.



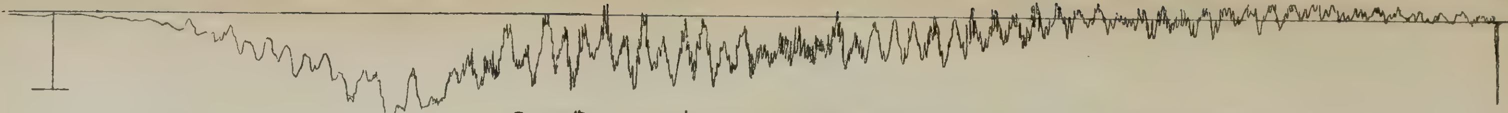
304#2 BOT. FL. PL. GIR. SPAN 30'-0" 8 M.P.H



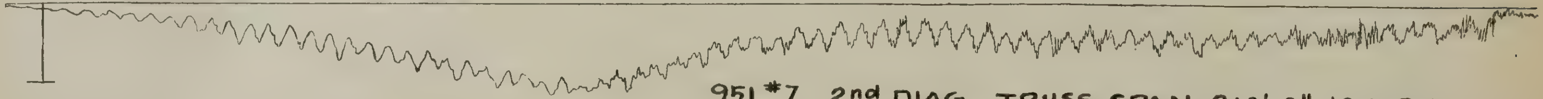
313 #2 BOT. FL., PL. GIR. SPAN 30'-0"
18 M.P.H.



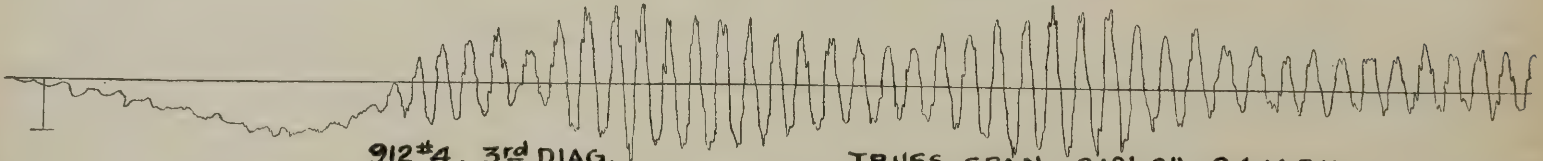
324#2. BOT.
PL. GIR. SP. 30'-0"
50 M.P.H.



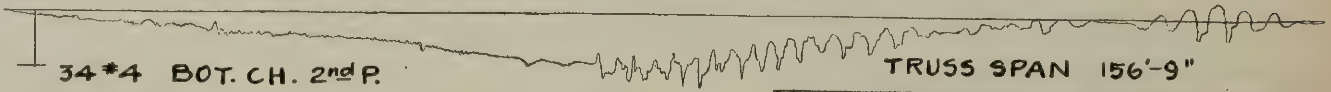
943#7. 2nd DIAG. TRUSS, SPAN 210'-0" 33 M.P.H.



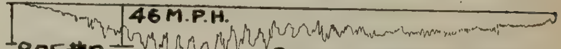
951#7 2nd DIAG. TRUSS SPAN 210'-0" 19 M.P.H.



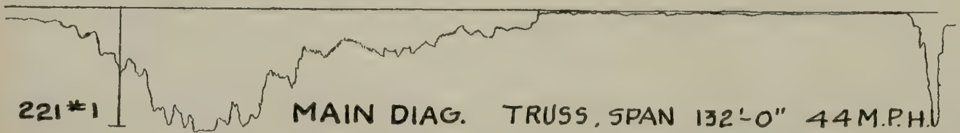
912#4. 3rd DIAG. TRUSS SPAN, 210'-0" 24 M.P.H.



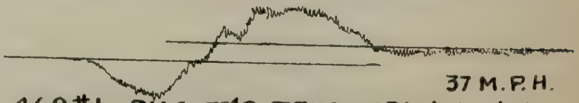
34#4 BOT. CH. 2nd P. TRUSS SPAN 156'-9"



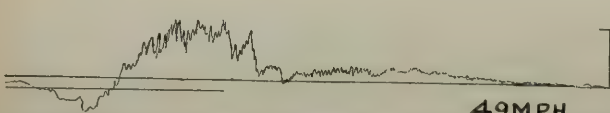
805#2 46 M.P.H. BOT. CH. TRUSS SP. 149'-0"



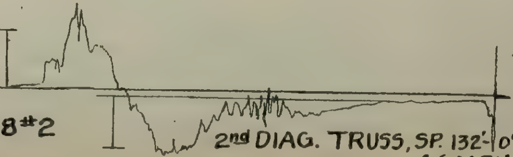
221#1 MAIN DIAG. TRUSS, SPAN 132'-0" 44 M.P.H.



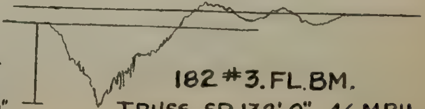
469#1, DIAG. 3rd P. TRUSS SPAN 152'-6" 37 M.P.H.



476#4 DIAG. 3rd P. TRUSS. SPAN 152'-6" 49 M.P.H.



158#2 2nd DIAG. TRUSS, SP. 132'-0" 46 M.P.H.



182#3. FL. BM. TRUSS, SP. 132'-0" 46 M.P.H.

PLATE II—c.

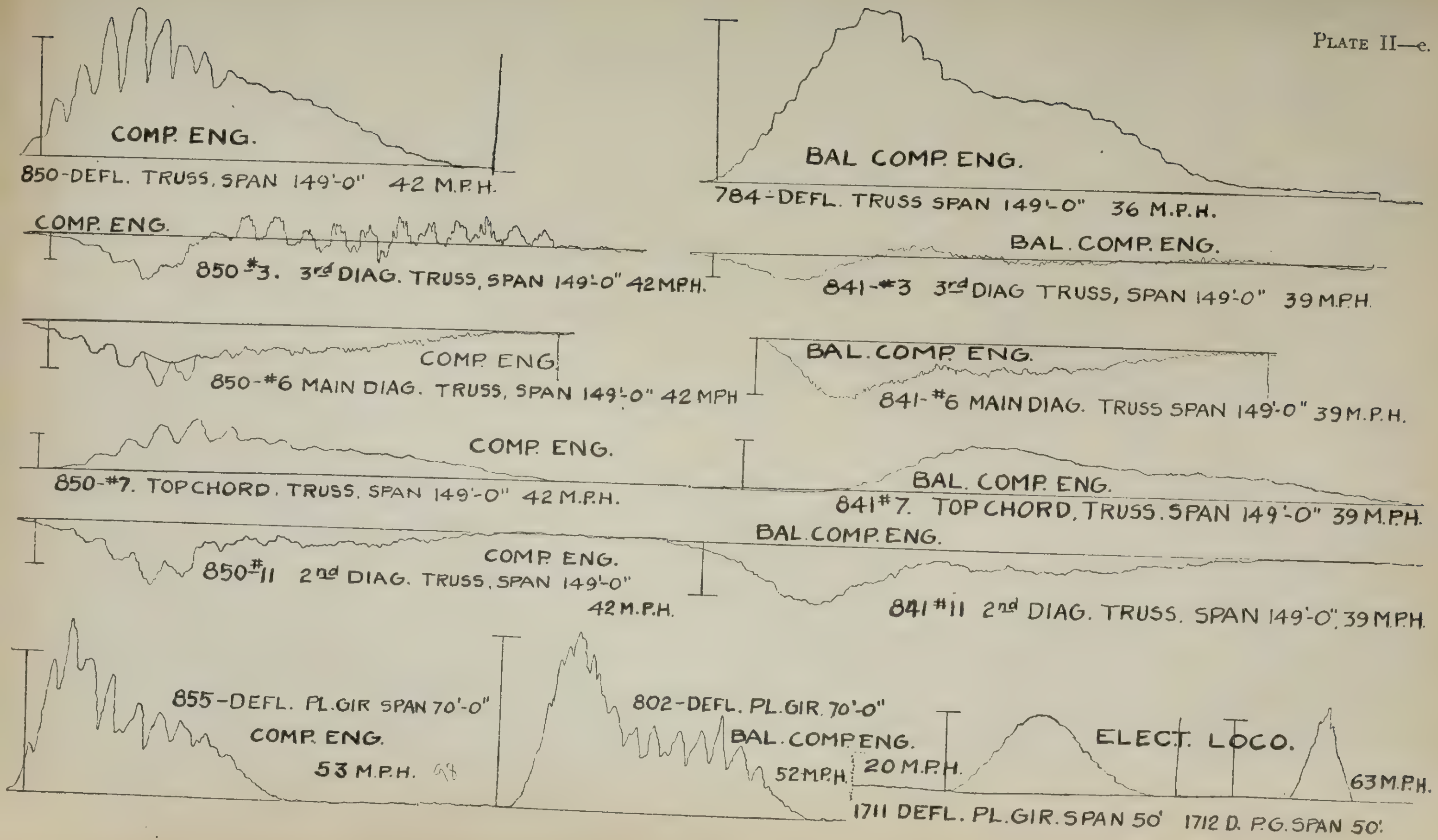
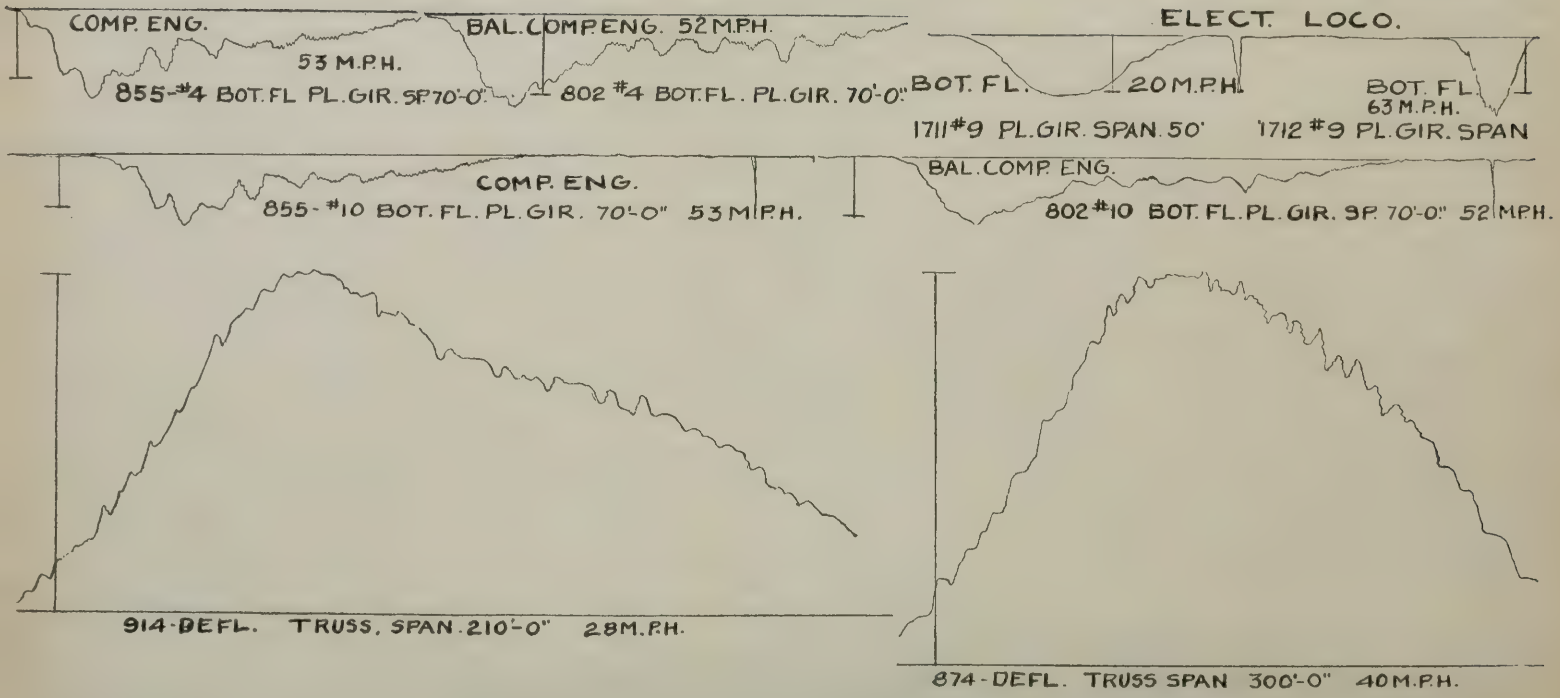
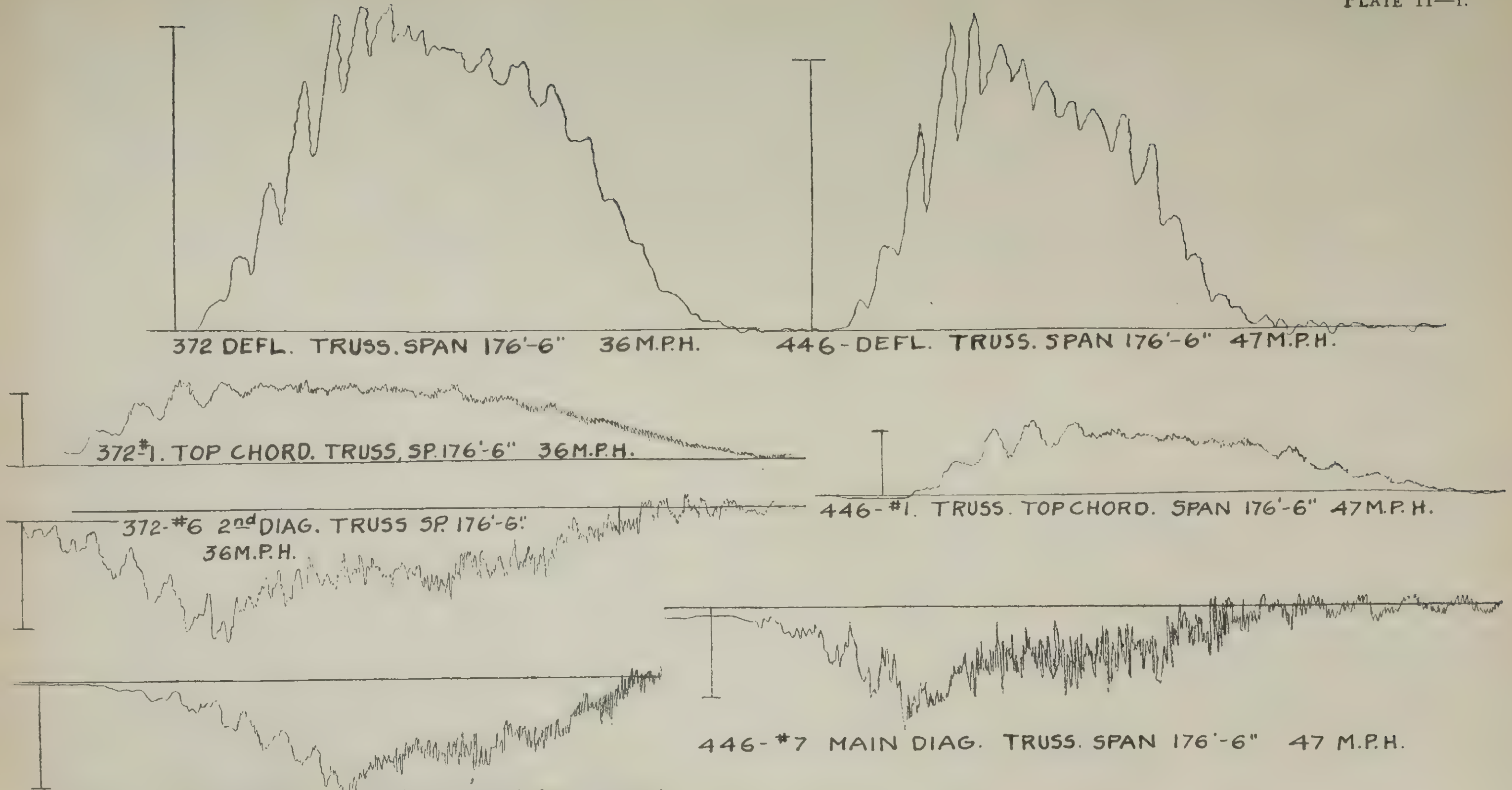

COMP. ENG.
850-DEFL. TRUSS, SPAN 149'-0" 42 M.P.H.
BAL COMP. ENG.
784-DEFL. TRUSS SPAN 149'-0" 36 M.P.H.
COMP. ENG.
850 #3. 3rd DIAG. TRUSS, SPAN 149'-0" 42 M.P.H.
BAL. COMP. ENG.
841-#3 3rd DIAG TRUSS, SPAN 149'-0" 39 M.P.H.
COMP. ENG.
850-#6 MAIN DIAG. TRUSS, SPAN 149'-0" 42 MPH
BAL. COMP. ENG.
841-#6 MAIN DIAG. TRUSS SPAN 149'-0" 39 M.P.H.
COMP. ENG.
850-#7. TOP CHORD. TRUSS. SPAN 149'-0" 42 M.P.H.
BAL. COMP. ENG.
841 #7. TOP CHORD. TRUSS. SPAN 149'-0" 39 M.P.H.
BAL. COMP. ENG.
COMP. ENG.
850 #11 2nd DIAG. TRUSS, SPAN 149'-0" 42 M.P.H.
841 #11 2nd DIAG. TRUSS. SPAN 149'-0", 39 M.P.H.
855-DEFL. PL. GIR SPAN 70'-0"
COMP. ENG.
53 M.P.H.
802-DEFL. PL. GIR. 70'-0"
BAL. COMP. ENG.
52 M.P.H.
20 M.P.H.
ELECT. LOCO.
63 M.P.H.
1711 DEFL. PL. GIR. SPAN 50'
1712 D. P.G. SPAN 50'

PLATE II—e—Continued.





372 DEFL. TRUSS. SPAN 176'-6" 36 M.P.H.

446-DEFL. TRUSS. SPAN 176'-6" 47 M.P.H.

372 #1. TOP CHORD. TRUSS. SP. 176'-6" 36 M.P.H.

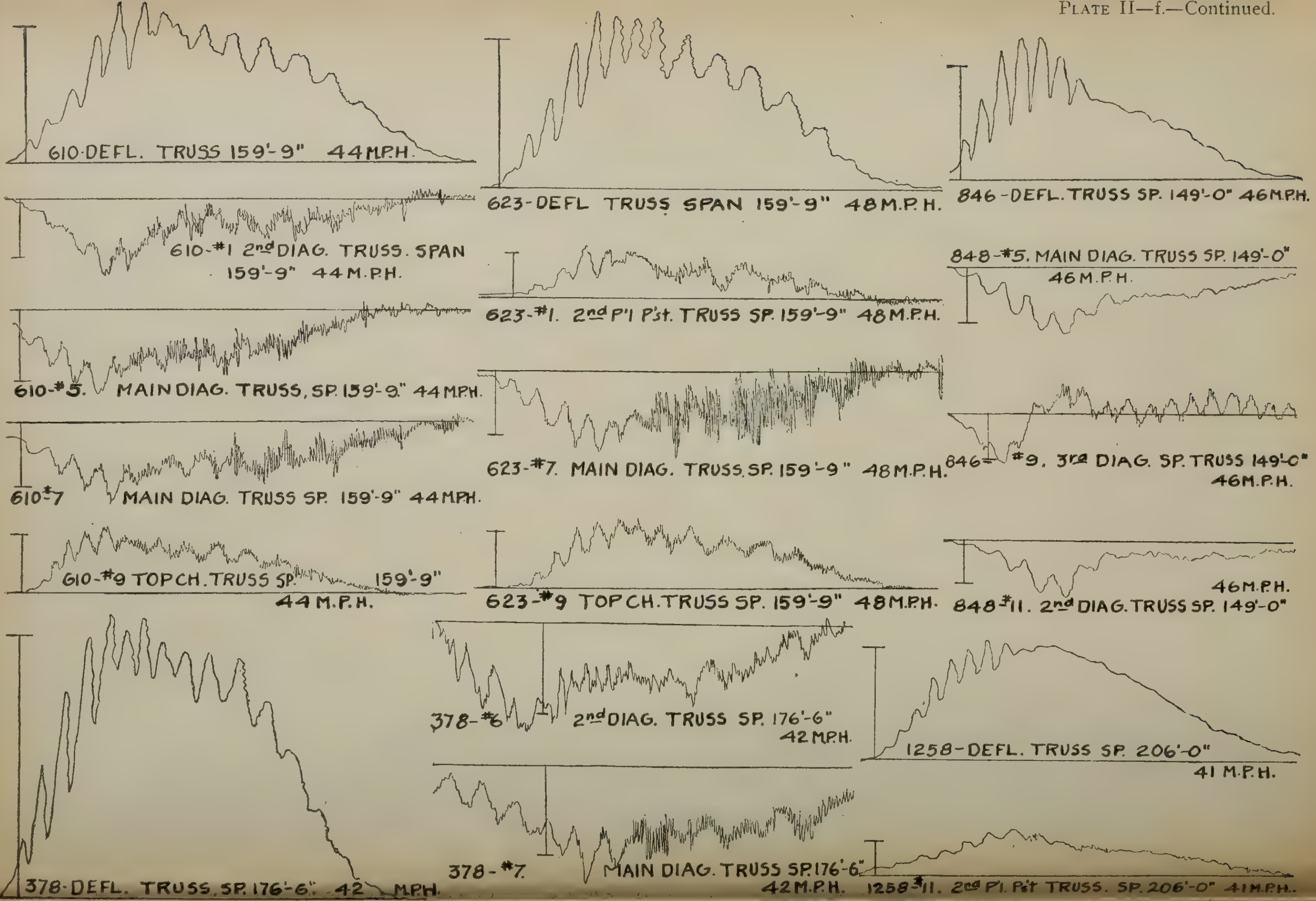
446-#1. TRUSS. TOP CHORD. SPAN 176'-6" 47 M.P.H.

372-#6 2nd DIAG. TRUSS SP. 176'-6". 36 M.P.H.

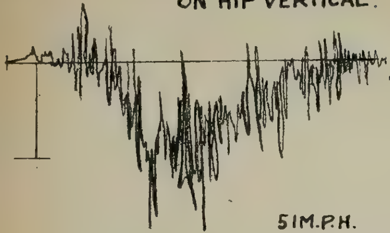
446-#7 MAIN DIAG. TRUSS. SPAN 176'-6" 47 M.P.H.

372 #7. MAIN DIAG. TRUSS SP. 176'-6". 36 M.P.H.

Plate II—f.—Continued.

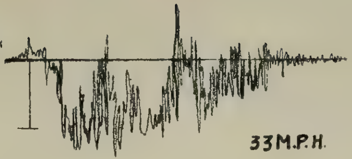


EFFECT OF RIGIDITY OF FlOOR ON HIP VERTICAL.



51M.P.H.

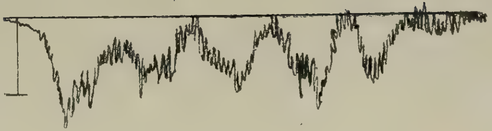
83-#4 HIPVERT. TR.SP. 112'-0"



33M.P.H.

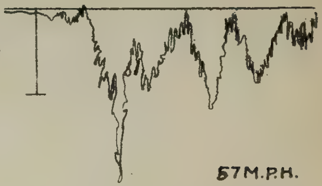
EFFECT OF RAIL JOINT AT CENTER OF STRINGER.

274-#7 STRINGER TR. SP. 132'-0"



RAIL JOINT AT CENTER OF STRINGER.

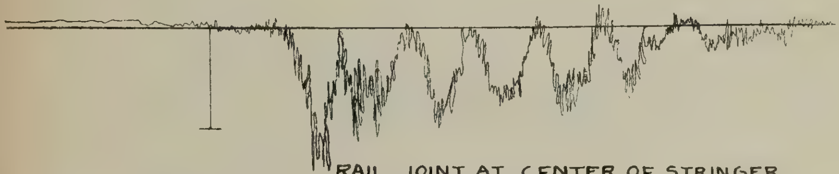
376-#5 STR. TRUSS SPAN. 176'-6". 40MPH.



57M.P.H.

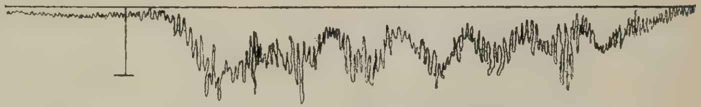
RAIL JOINT AT CENTER OF STRINGER

414-#5 STR. TR. SP. 176-6"



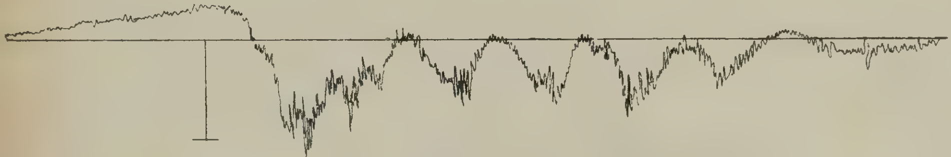
RAIL JOINT AT CENTER OF STRINGER.

534#3 BOT.FL. STR. TRUSS, SPAN 228'-0" 44 M.P.H.



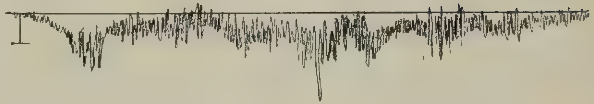
EFFECT OF SHORT TIE ON STRINGER RECORD.

877-#1. BOT.FL.STR. TRUSS, SPAN 300'-0" 39M.P.H.



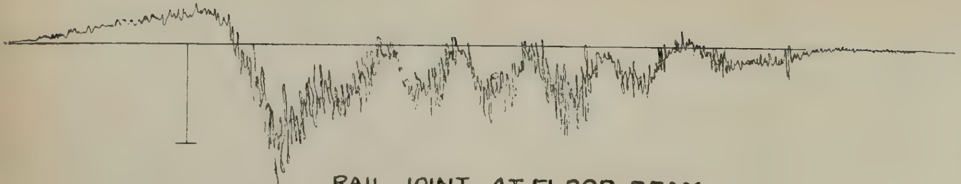
RAIL JOINT AT FLOOR BEAM

536#1 BOT.FL. F.B. TRUSS, SPAN 228'-0" 39M.P.H.



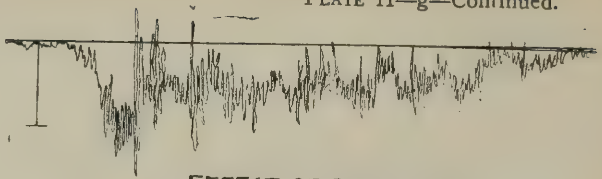
EFFECT OF SHORT TIE.

877-#11. BOT. FL. STR. TRUSS, SP. 300'-0" 39M.P.H.



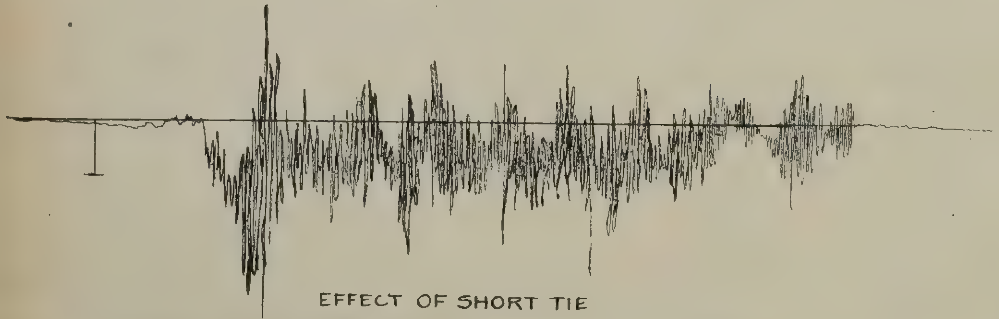
RAIL JOINT AT FLOOR BEAM.

550-#1. BOT. FL. F.B. TRUSS. SPAN 228'-0" 48 M.P.H.



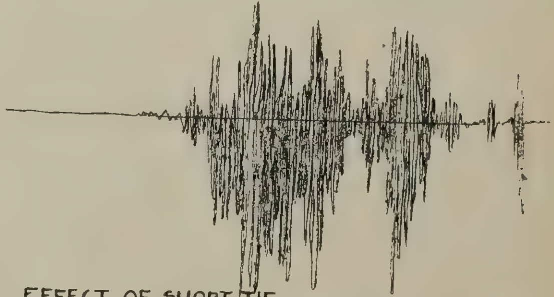
EFFECT OF SHORT TIE.

1090-#5 BOT. FL. STR. TRUSS, SPAN 151'-11½" 38 M.P.H.



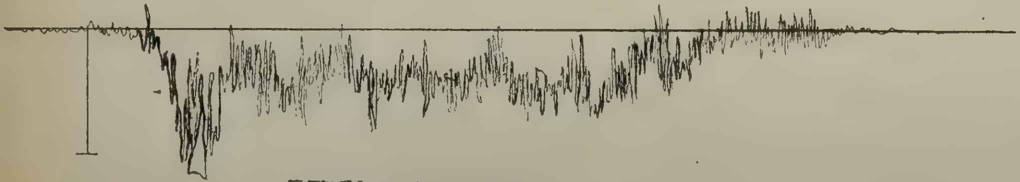
EFFECT OF SHORT TIE

1251-#8 BOT. FL. STR. TRUSS. SPAN 206'-0" 37 M.P.H.



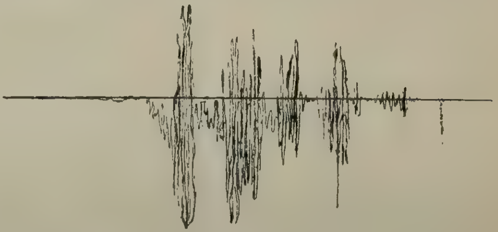
EFFECT OF SHORT TIE.

1448-#4 STR. TRUSS SPAN 104'-0" 48 M.P.H.



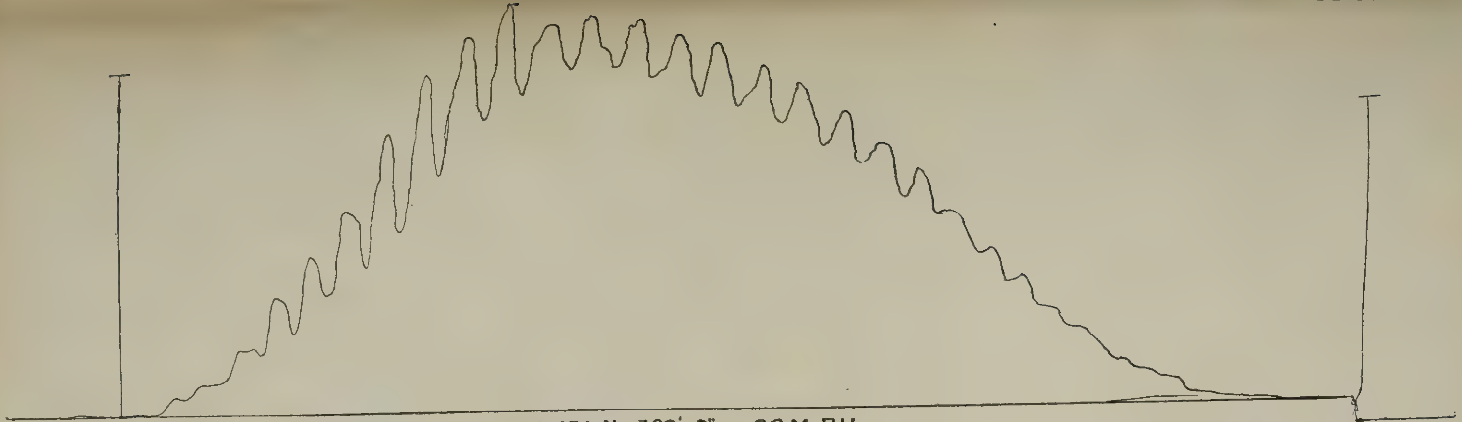
EFFECT OF SHORT TIE

1118-#2 BOT. FL. STR. TRUSS SPAN 152'-10" 31 M.P.H.

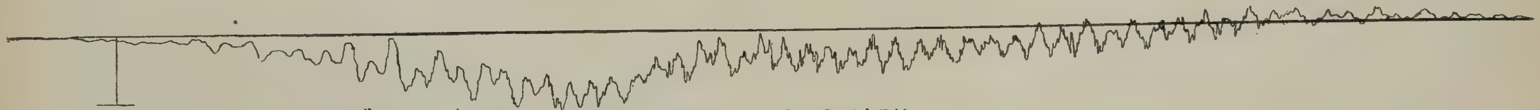


EFFECT OF SHORT TIE.

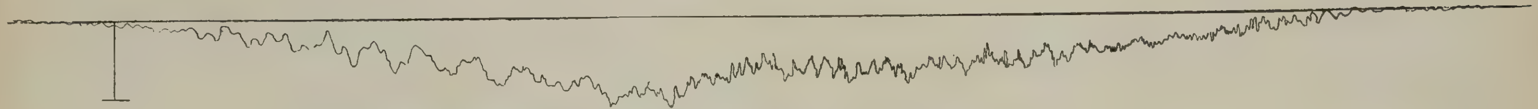
1448-#12. BOT. FL. STR. TRUSS, SP. 104'-0" 48 M.P.H.



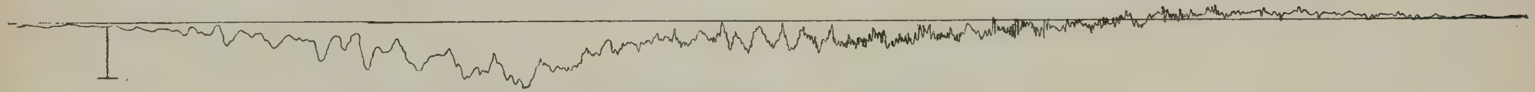
894-DEFL TRUSS, SPAN 300'-0" 29 M.P.H



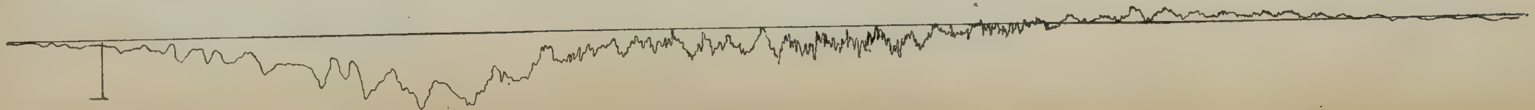
894-#4. 2nd DIAG. TRUSS. SPAN. 300'-0" 29 M.P.H.



894-#6 MAIN DIAG. TRUSS, SPAN 300'-0" 29 M.P.H.



894-#7. 3rd DIAG. TRUSS. SPAN 300'-0" 29 M.P.H.



894-#9 4th DIAG. TRUSS, SPAN 300'-0" 29 M.P.H.

PLATE II—i.

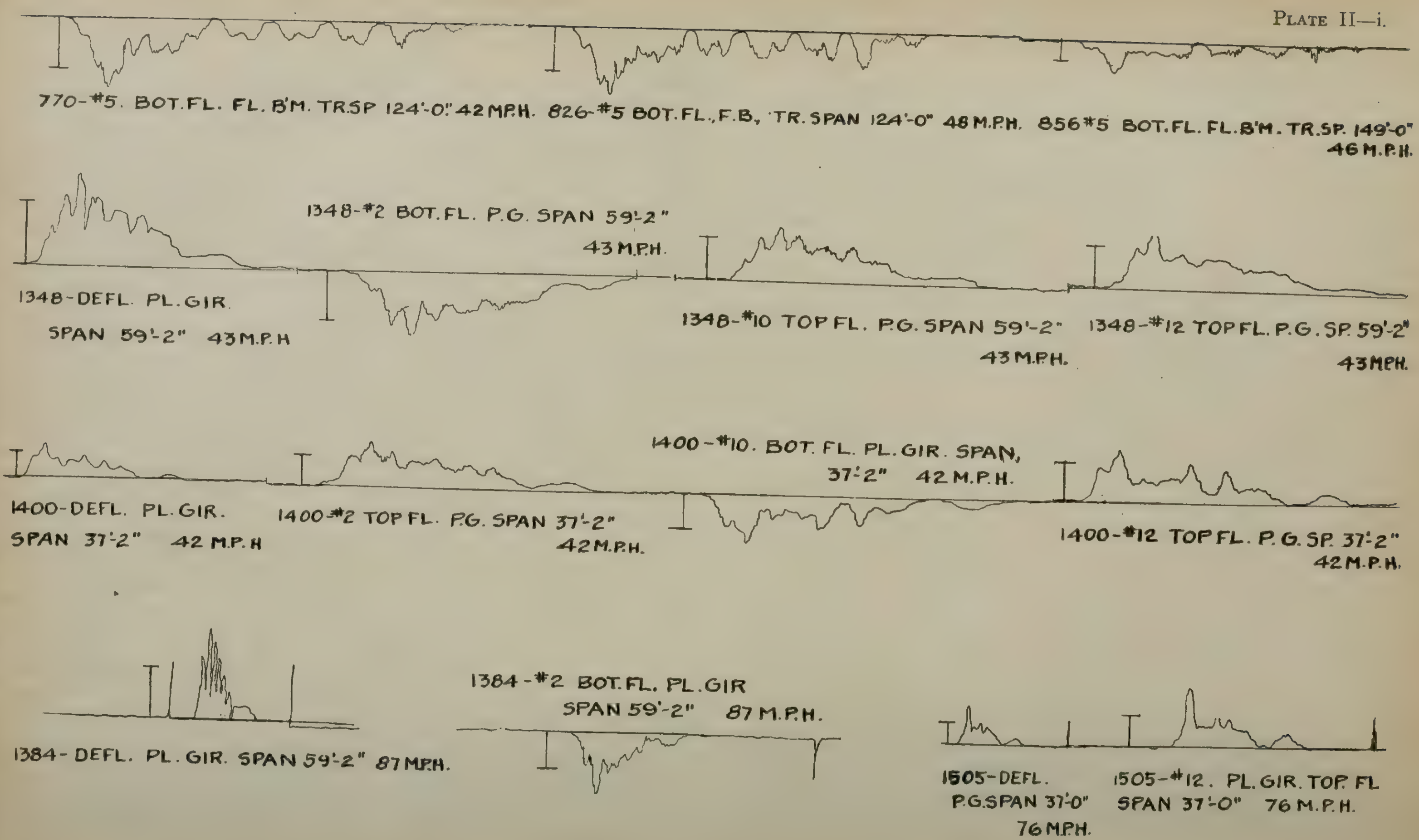
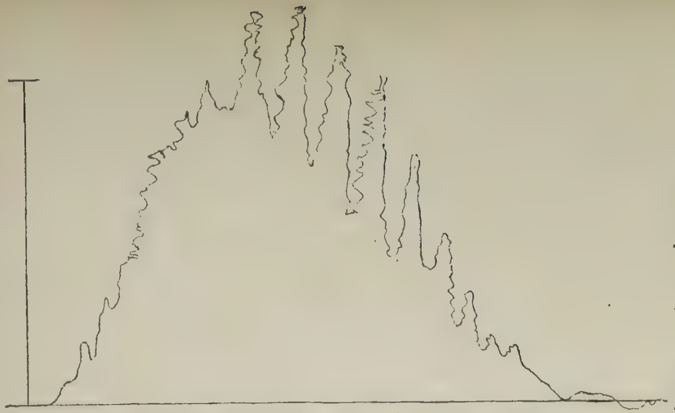
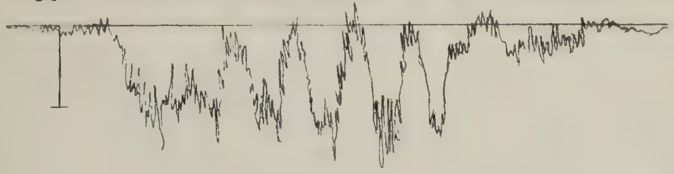

770-#5. BOT.FL. FL. B'M. TR.SP 124'-0" 42 M.P.H.
826-#5 BOT.FL., F.B., TR. SPAN 124'-0" 48 M.P.H.
856 #5 BOT.FL. FL.B'M. TR.SP. 149'-0" 46 M.P.H.
1348-DEFL. PL. GIR. SPAN 59'-2" 43 M.P.H
1348-#2 BOT.FL. P.G. SPAN 59'-2" 43 M.P.H.
1348-#10 TOP FL. P.G. SPAN 59'-2" 43 M.P.H.
1348-#12 TOP FL. P.G. SP. 59'-2" 43 M.P.H.
1400-DEFL. PL. GIR. SPAN 37'-2" 42 M.P.H
1400-#2 TOP FL. P.G. SPAN 37'-2" 42 M.P.H.
1400-#10. BOT. FL. PL. GIR. SPAN, 37'-2" 42 M.P.H.
1400-#12 TOP FL. P.G. SP. 37'-2" 42 M.P.H.
1384-DEFL. PL. GIR. SPAN 59'-2" 87 M.P.H.
1384-#2 BOT. FL. PL. GIR SPAN 59'-2" 87 M.P.H.
1505-DEFL. P.G. SPAN 37'-0" 76 M.P.H.
1505-#12. PL. GIR. TOP. FL SPAN 37'-0" 76 M.P.H.

Plate II—J.

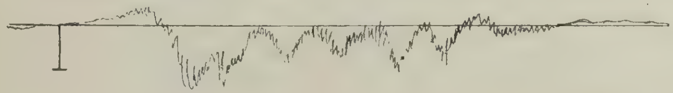


585-DEFL. TRUSS SPAN 228'-0" 59 M.P.H.

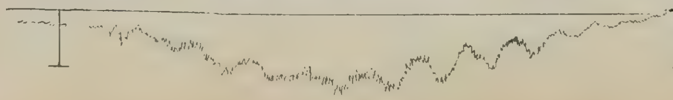
585-#1. BOT. FL. STR. TRUSS SP. 228'-0" 59 M.P.H.

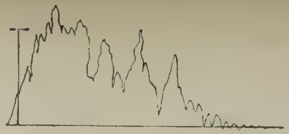


585-#3 BOT. FL. F.B. TRUSS SP. 228'-0" 59 M.P.H.



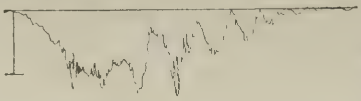
585 #4 BOT. FL. END F.B. TRUSS, SP. 228'-0" 59 M.P.H.



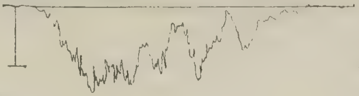


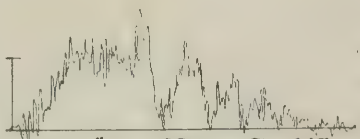
743-DEFL. TRUSS, SPAN 64'-0" 64 M.P.H.

743-#2 BOT. FL. PL. GIR. SPAN 92'-6" 64 M.P.H.

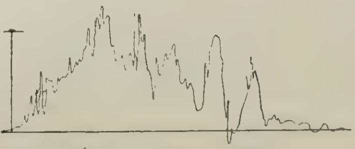


743 #3 BOT. CH. TRUSS. SPAN 64'-0" 64 M.P.H.

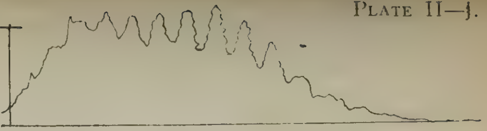




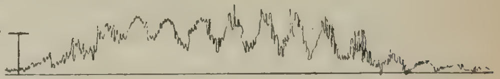
743- #4 TOP FL. PL. GIR. SPAN 92'-6" 64 M.P.H.



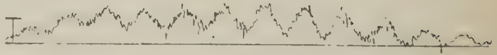
743-#5 TOP FL. P.G. SPAN 92'-6" 64 M.P.H.



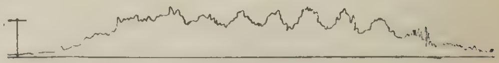
1193-DEFL TRUSS, SPAN 126'-0" 40 M.P.H.



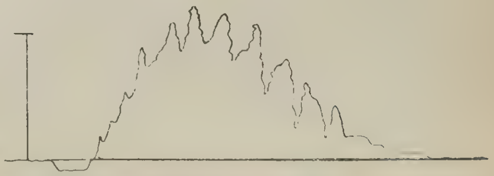
1193-#8. END POST. TR. SP. 126'-0" 40 M.P.H.



1193- #9 END POST. TRUSS SP. 126'-0". 40 MPH

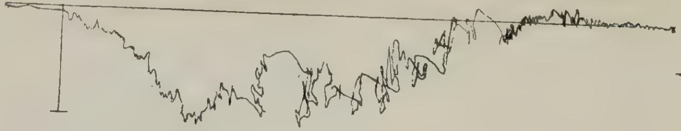


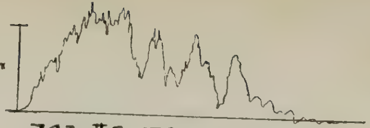
1193-#10 TOP CH. TRUSS SPAN 126'-0" 40 MPH.

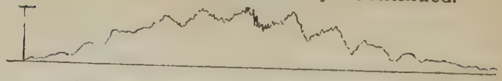


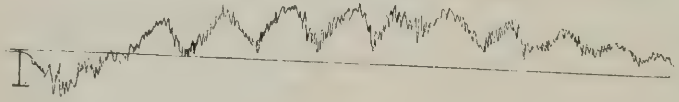
1288-DEFL. TRUSS SP. 206'-0" 61 M.P.H.

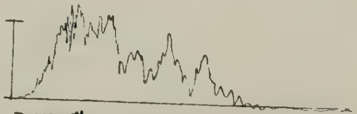
Plate II—j—Continued.

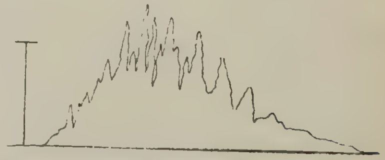

585-#5 MAIN DIAG. TRUSS SPAN 228'-0" 59 M.P.H.

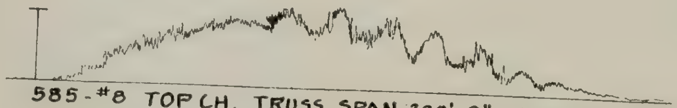

743-#8 TOP CH. TRUSS SPAN 64'-0" 64 M.P.H.


1288-#9 TOP CH. TRUSS SP. 206'-0" 61 M.P.H.

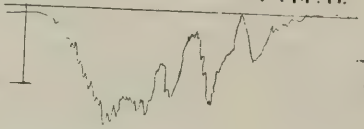

585-#6 BOT. FL. END FL. B'M. TRUSS SP. 228'-0" 59 M.P.H.

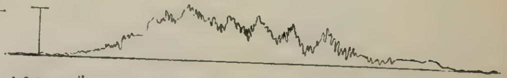

743-#9 TOP. CH. TRUSS SPAN 64'-0" 64 M.P.H.

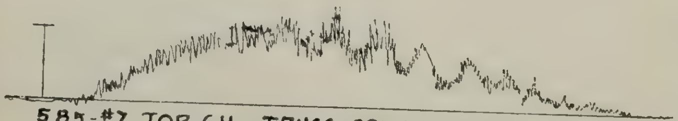

1428-DEFL. TRUSS SP. 104'-0" 42 M.P.H.


585-#8 TOP CH. TRUSS, SPAN 228'-0" 59 M.P.H.

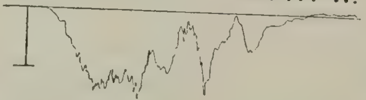
743-#11 MAIN DIAG. TRUSS SPAN 64'-0" 64 M.P.H.

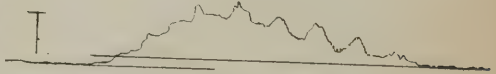


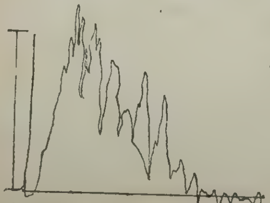

1428-#5 END POST. TRUSS SP. 104'-0" 42 M.P.H.


585-#7 TOP CH. TRUSS, SPAN 228'-0" 59 M.P.H.

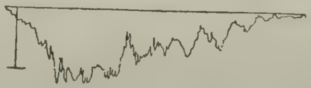
743-#12 BOT. CH. TRUSS SPAN 64'-0" 64 M.P.H.



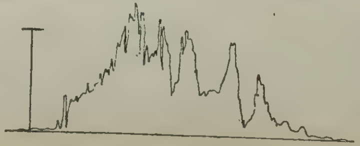

1428-#6 TOP CH. TR. SP. 104'-0". 42 M.P.H.


724-DEFL. P.G. SPAN 92'-6" 64 M.P.H.

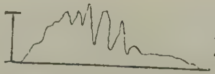
724-#2 BOT. FL. P.G. SPAN 92'-6" 64 M.P.H

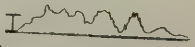


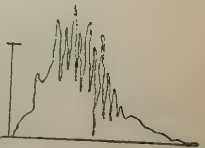
724-#5 TOP FL. PL. GIR SPAN 92'-6" 64 M.P.H

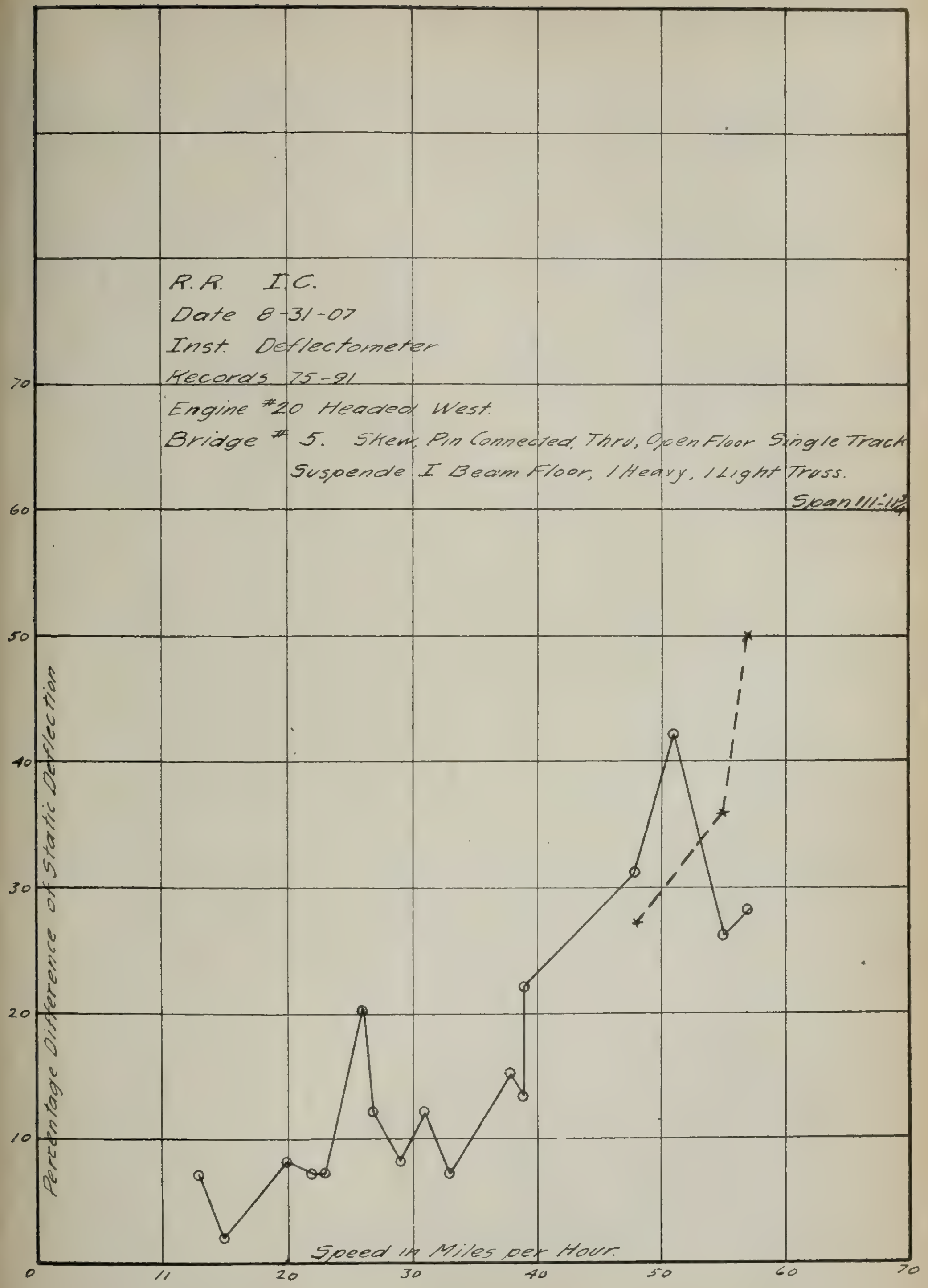


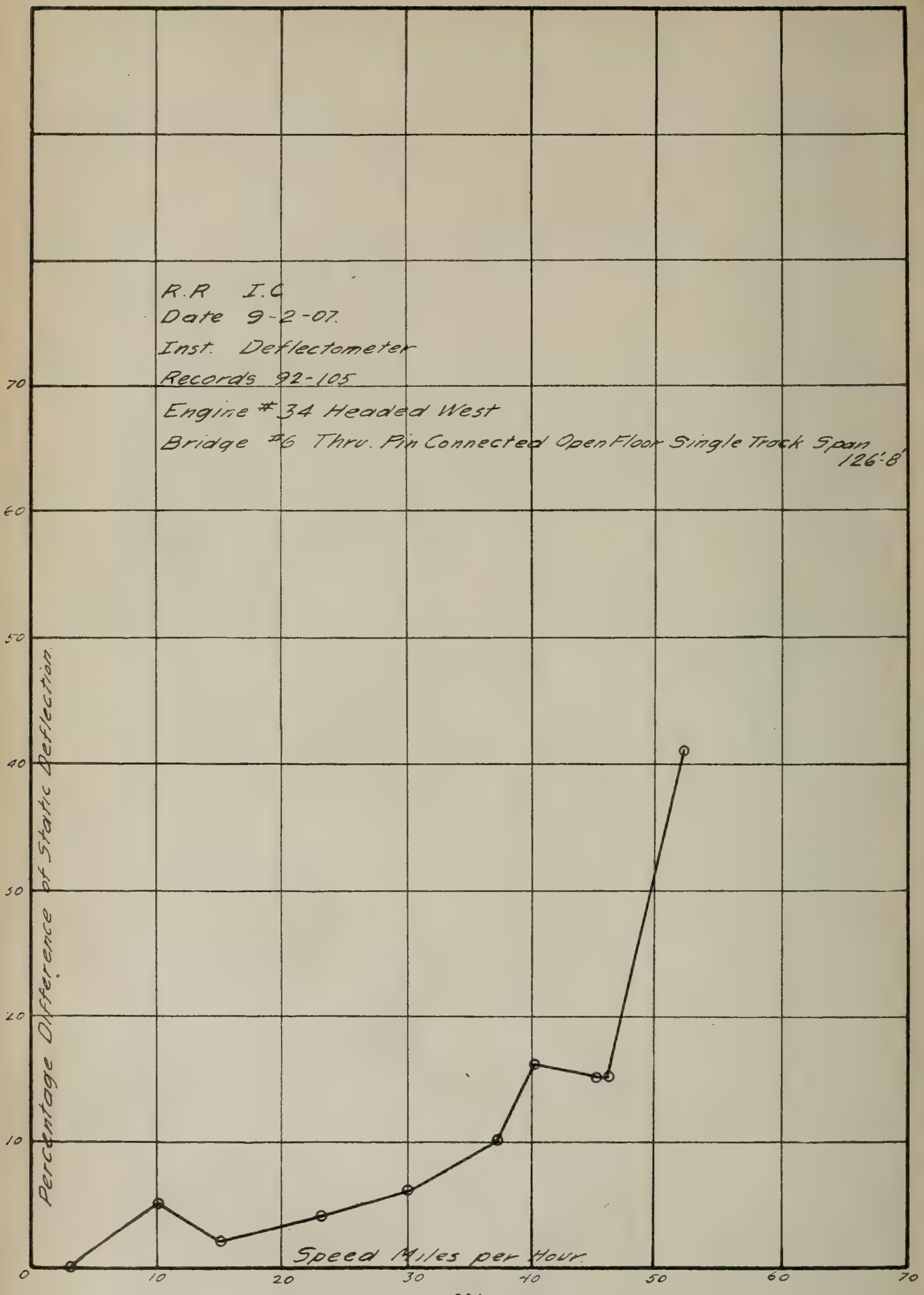
25

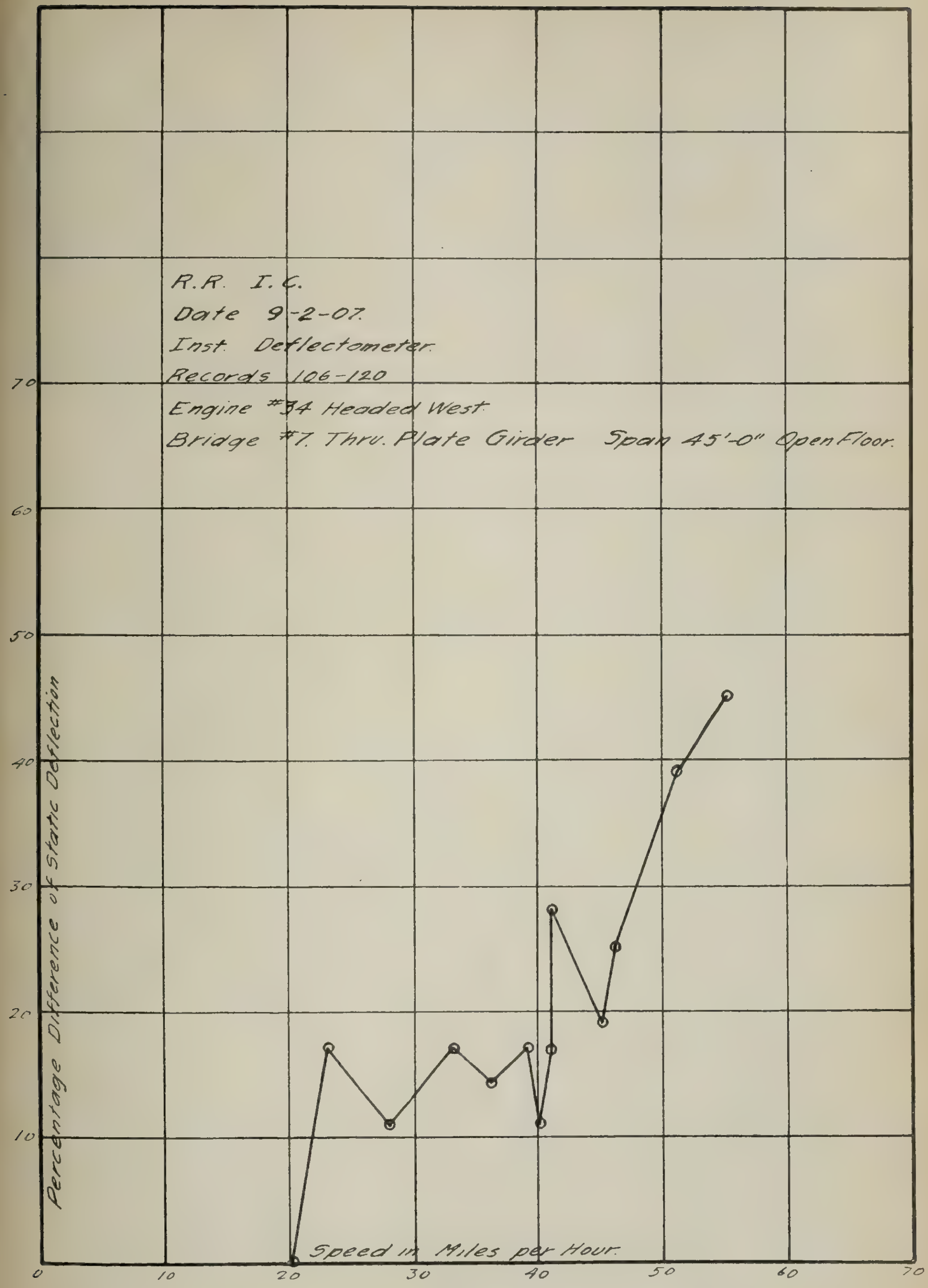

1330-DEFL. PL. GIR SPAN. 47'-10½" 52 M.P.H.

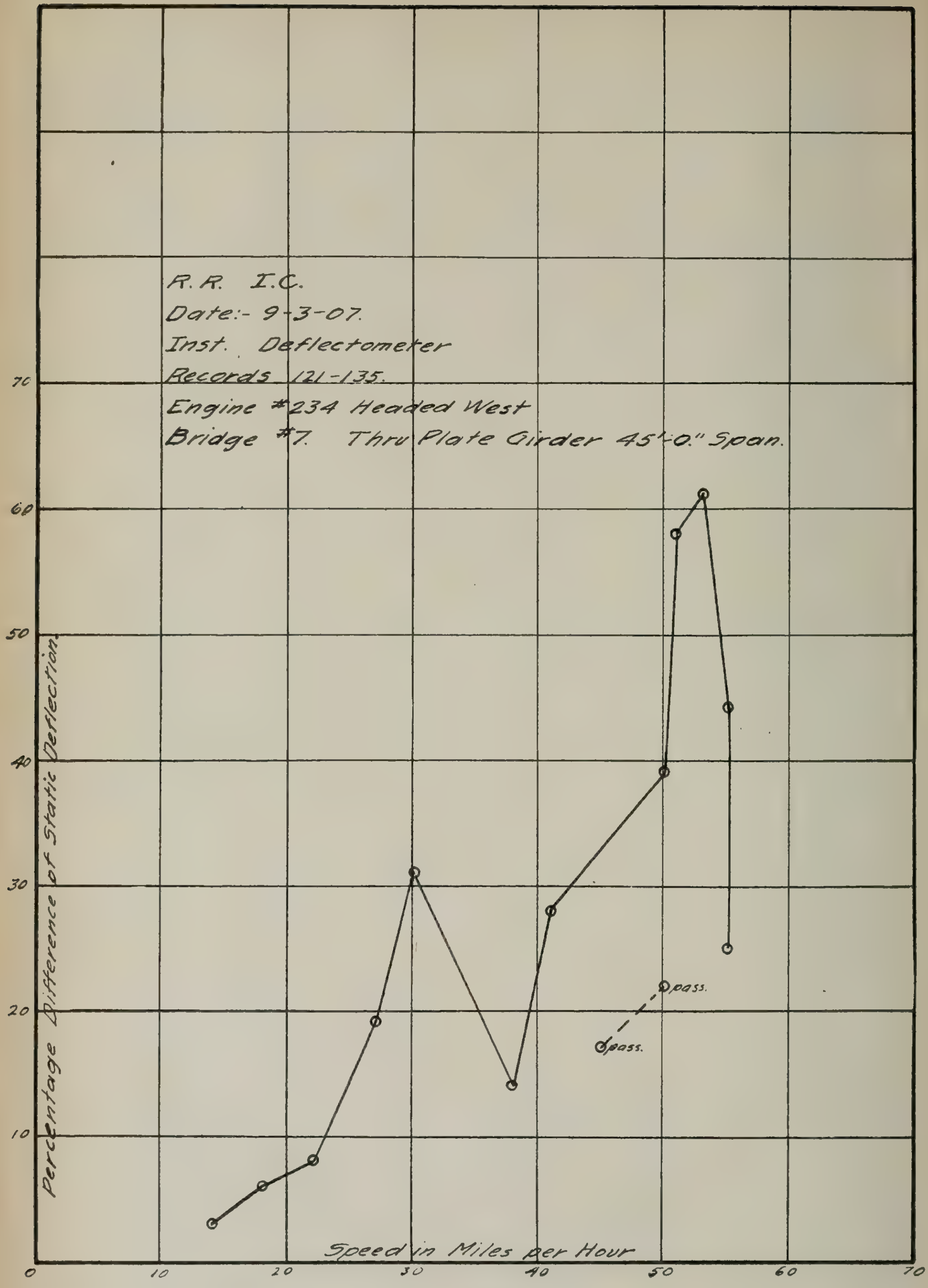

1330-#6 TOP FL. P.G. SPAN 47'-10½" 52 M.P.H.


1452-DEFL. TRUSS SPAN 104'-0" 63 M.P.H.


R.R. I.C.
Date 8-31-07
Inst. Deflectometer
Records 75-91
Engine #20 Headed West.
Bridge # 5. Skew, Pin Connected, Thru, Open Floor Single Track
Suspende I Beam Floor, 1 Heavy, 1 Light Truss.
Span 111'-11
Percentage Difference of Static Deflection
Speed in Miles per Hour.
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70


R.R I.C
Date 9-2-07.
Inst. Deflectometer
Records 92-105
Engine # 34 Headed West
Bridge # 6 Thru. Pin Connected Open Floor Single Track Span 126'-8"
Percentage Difference of Static Deflection
Speed Miles per Hour.
0
10
20
30
40
50
60
70


R.R. I.C.
Date 9-2-07.
Inst. Deflectometer.
Records 106-120
Engine #34 Headed West
Bridge #7. Thru. Plate Girder Span 45'-0" Open Floor.
Percentage Difference of Static Deflection
Speed in Miles per Hour.
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70


R. R. I. C.
Date:- 9-3-07.
Inst. Deflectometer
Records 121-135.
Engine #234 Headed West
Bridge #7. Thru Plate Girder 45'-0." Span.
pass.
pass.
Percentage Difference of Static Deflection
Speed in Miles per Hour
0
10
20
30
40
50
60
70
10
20
30
40
50
60
70

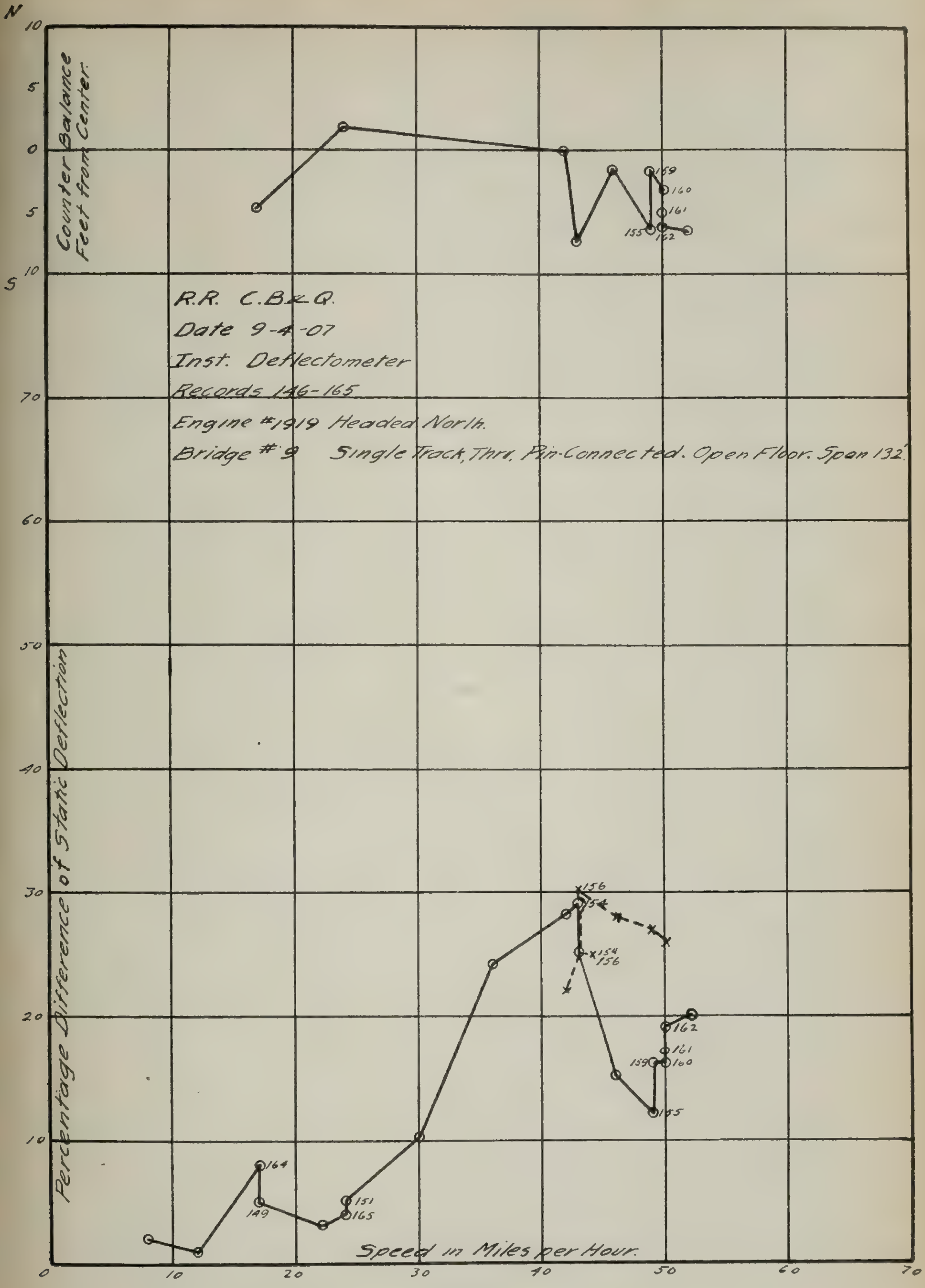
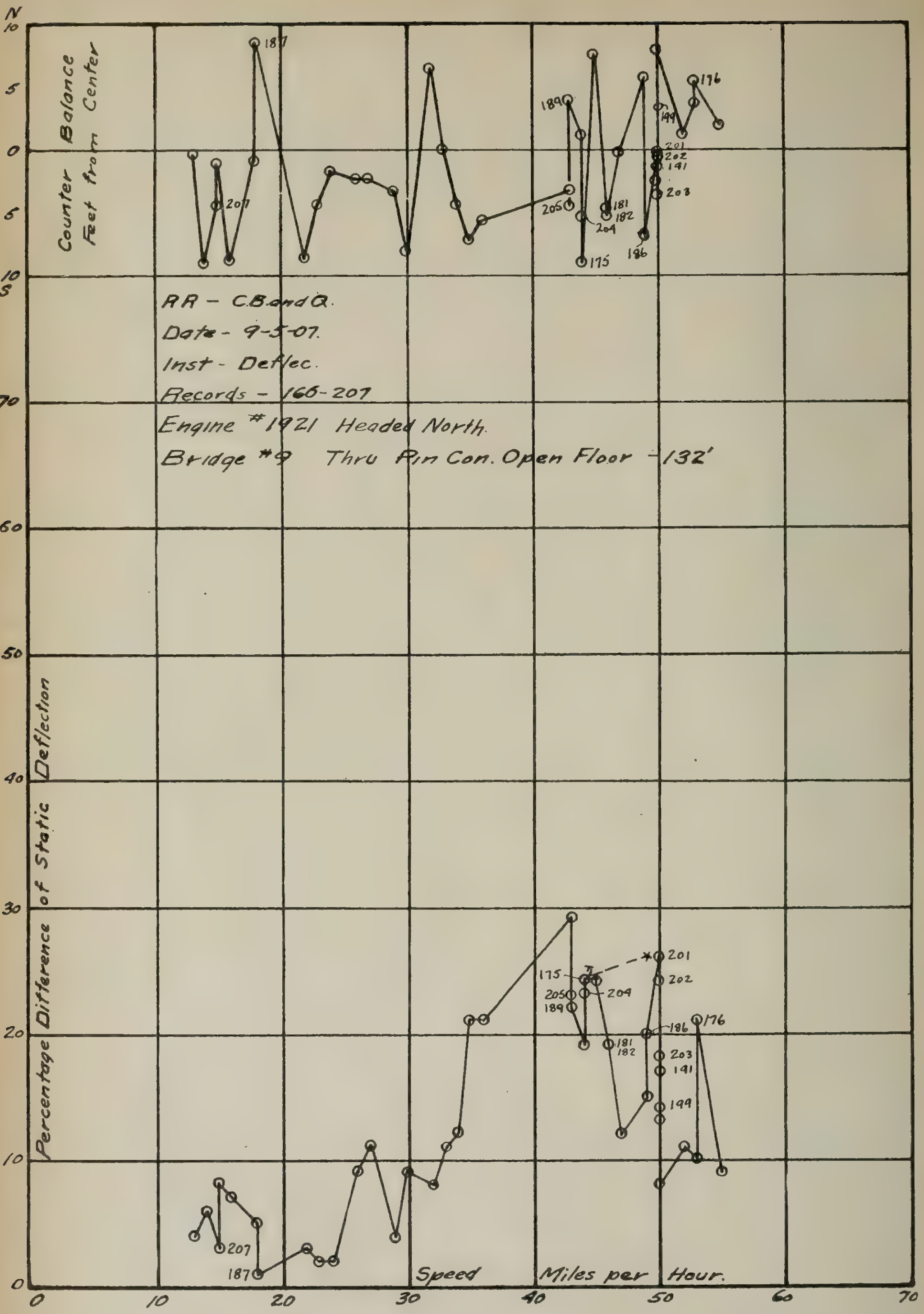
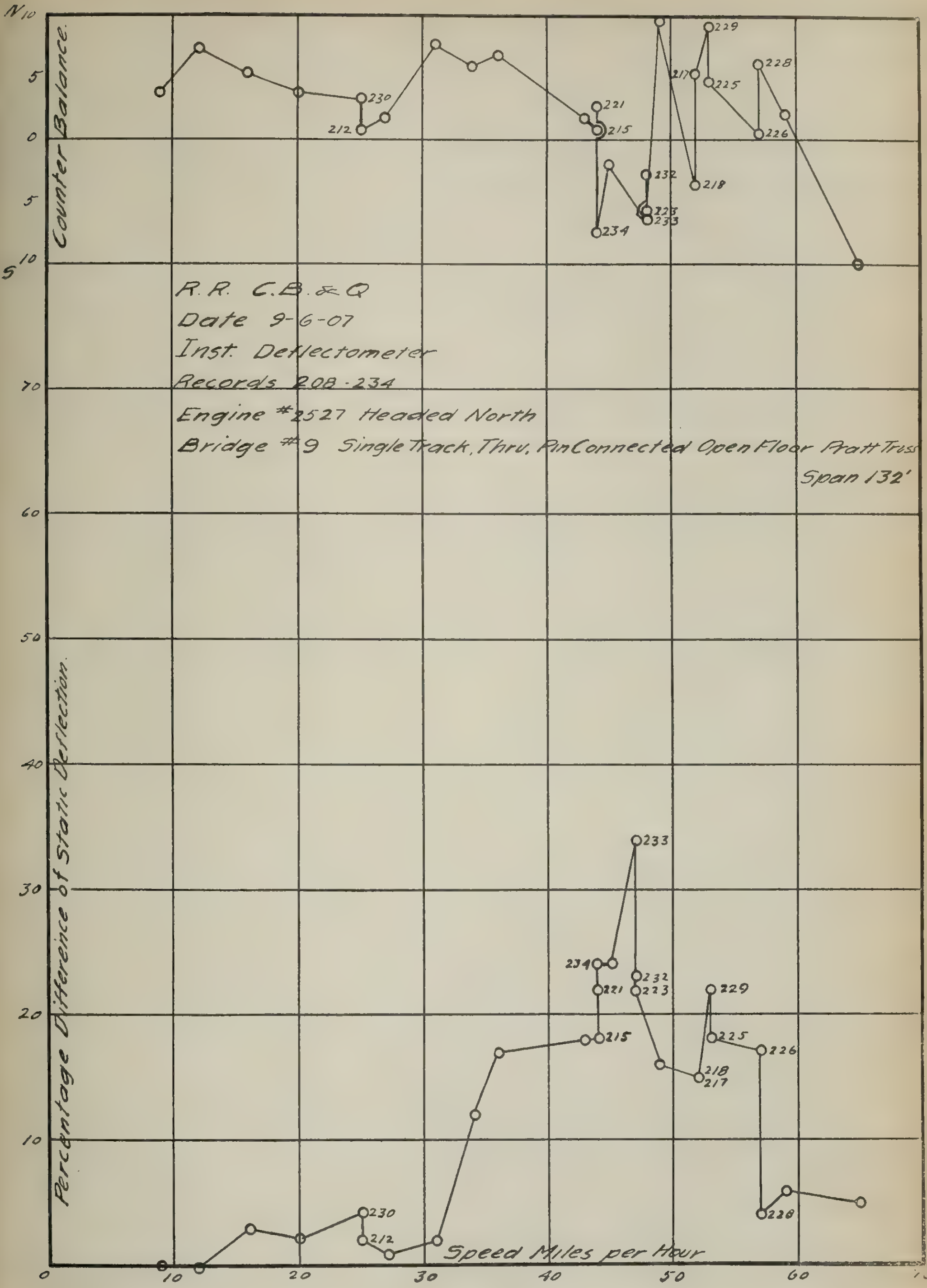

N
S
Counter Balance Feet from Center.
R.R. C.B.&Q.
Date 9-4-07
Inst. Deflectometer
Records 146-165
Engine #1919 Headed North.
Bridge #9 Single Track, Thru. Pin-Connected. Open Floor. Span 132'.
Percentage Difference of Static Deflection
Speed in Miles per Hour.
10
5
0
5
10
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
159
160
161
155
162
156
154
154
156
162
161
159
160
155
164
149
151
165

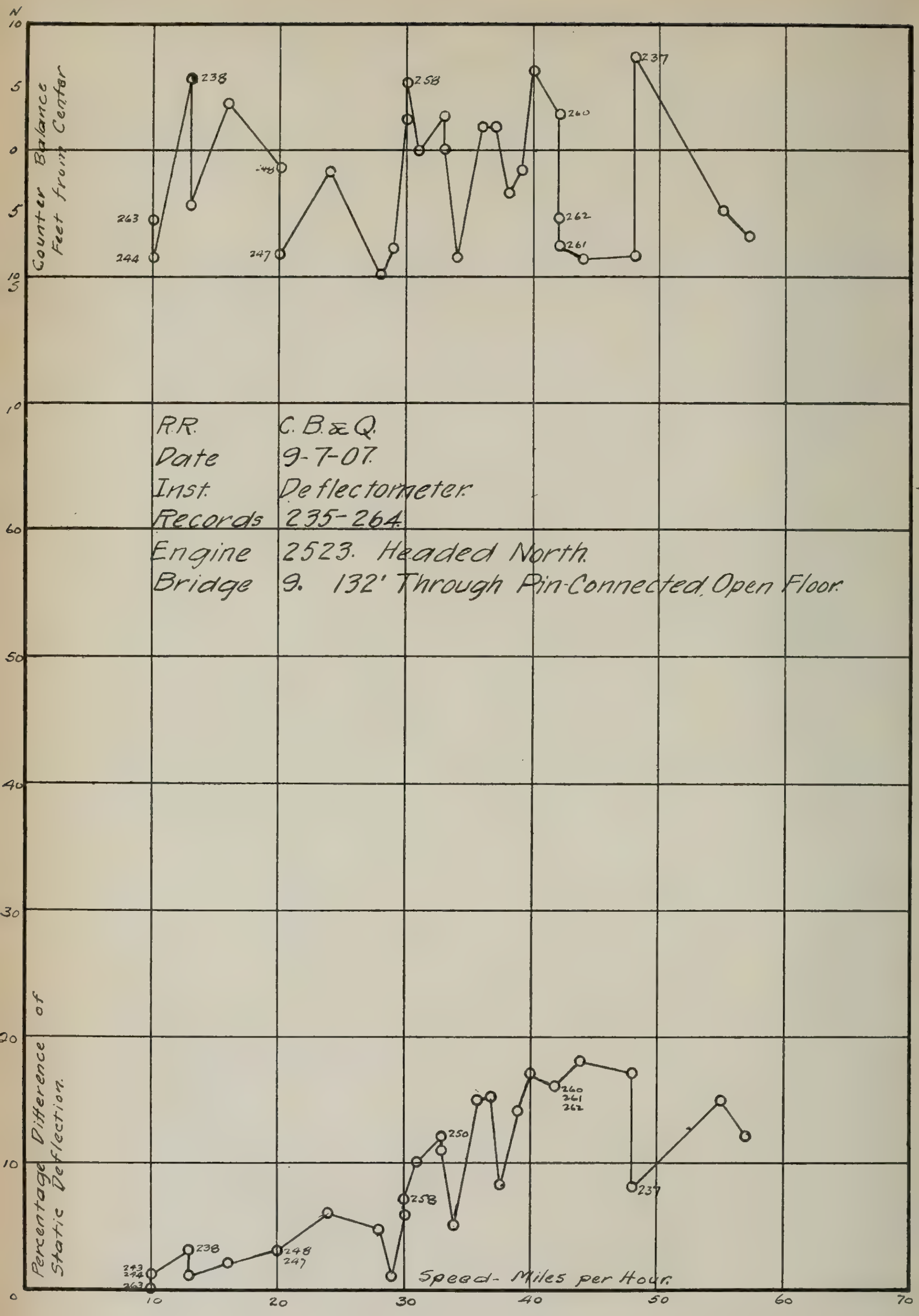
PLATE III—f.

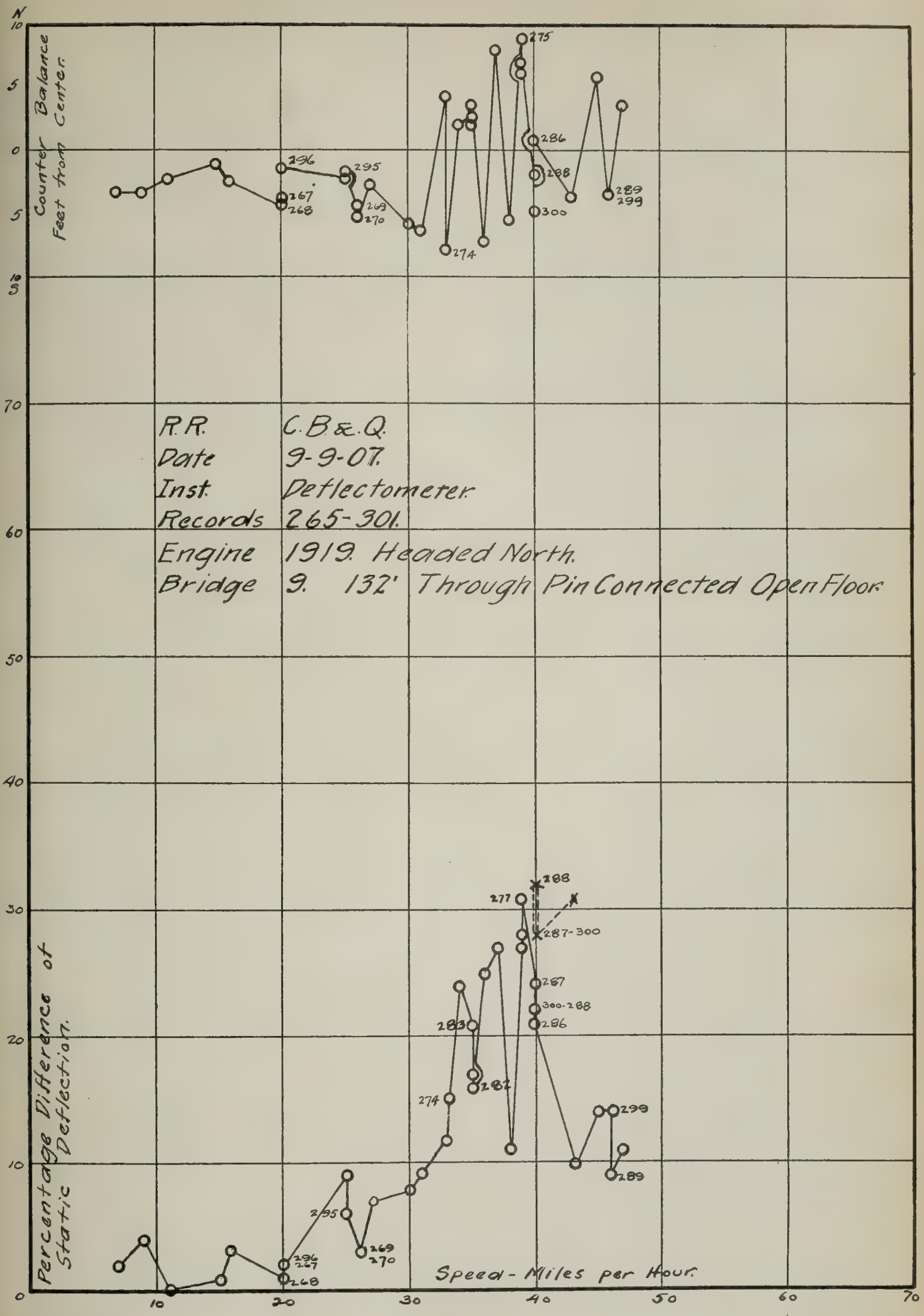

N
10
5
0
5
10
S
Counter Balance
Feet from Center
RR - C.B.and Q.
Date - 9-5-07.
Inst - Deflec.
Records - 166-207
Engine #1921 Headed North.
Bridge #9 Thru Pin Con. Open Floor - 132'
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
Speed Miles per Hour.
0
10
20
30
40
50
60
70
187
207
189
205
204
175
181
182
186
199
201
202
141
203
176

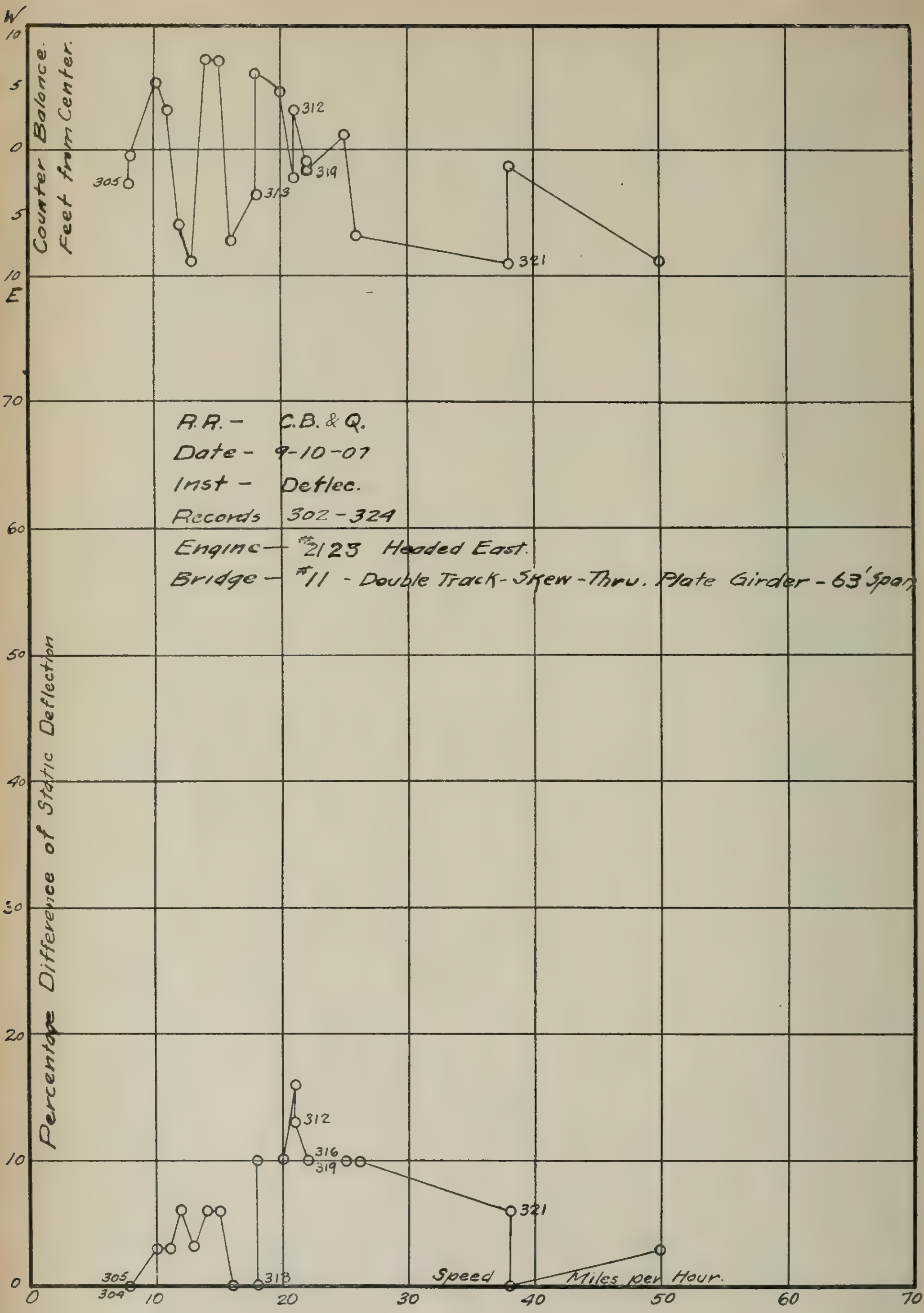


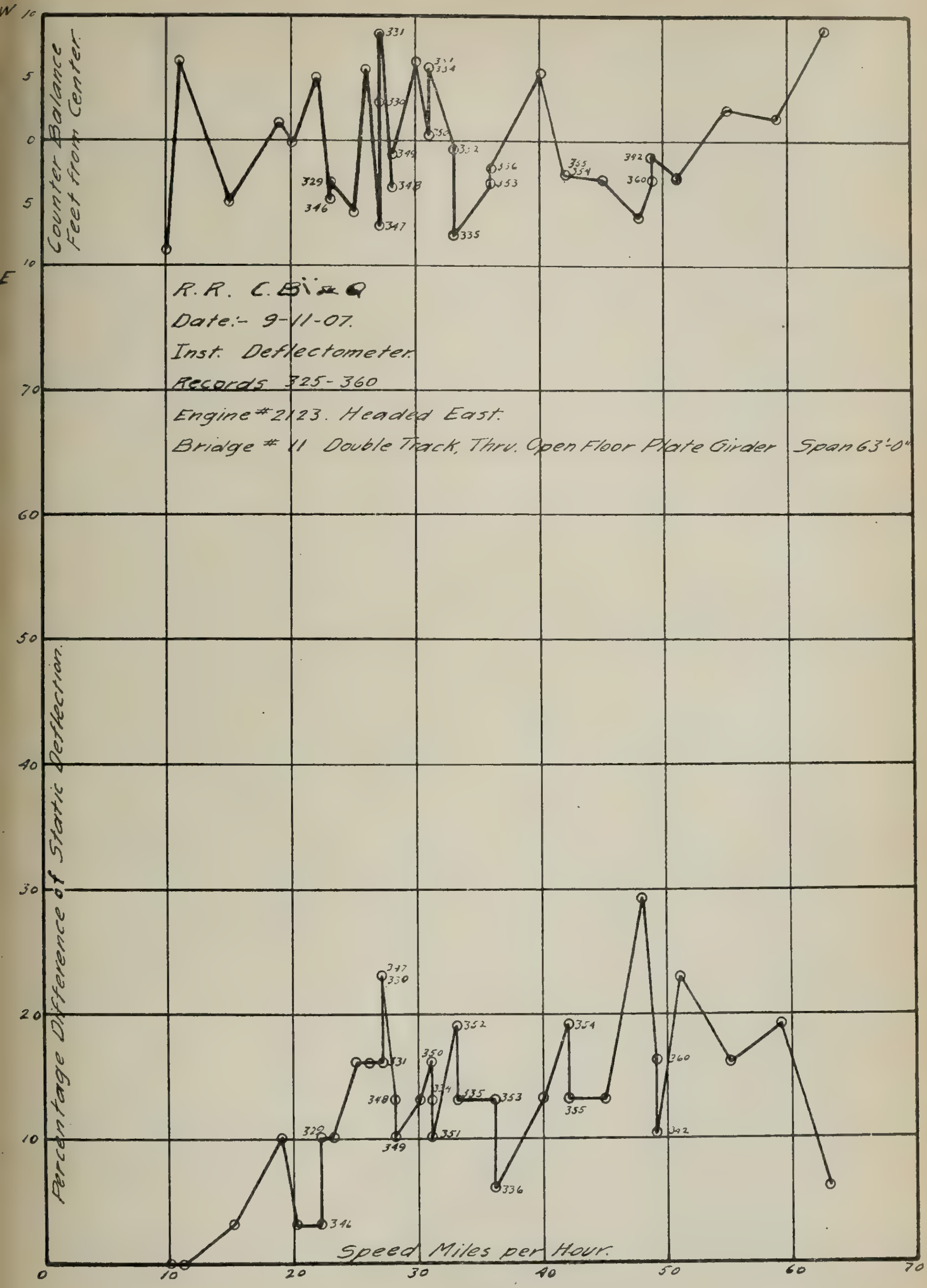
R.R. C.B. & Q
Date 9-6-07
Inst. Deflectometer
Records 208-234
Engine #2527 Headed North
Bridge #9 Single Track, Thru, Pin Connected Open Floor Pratt Truss
Span 132'

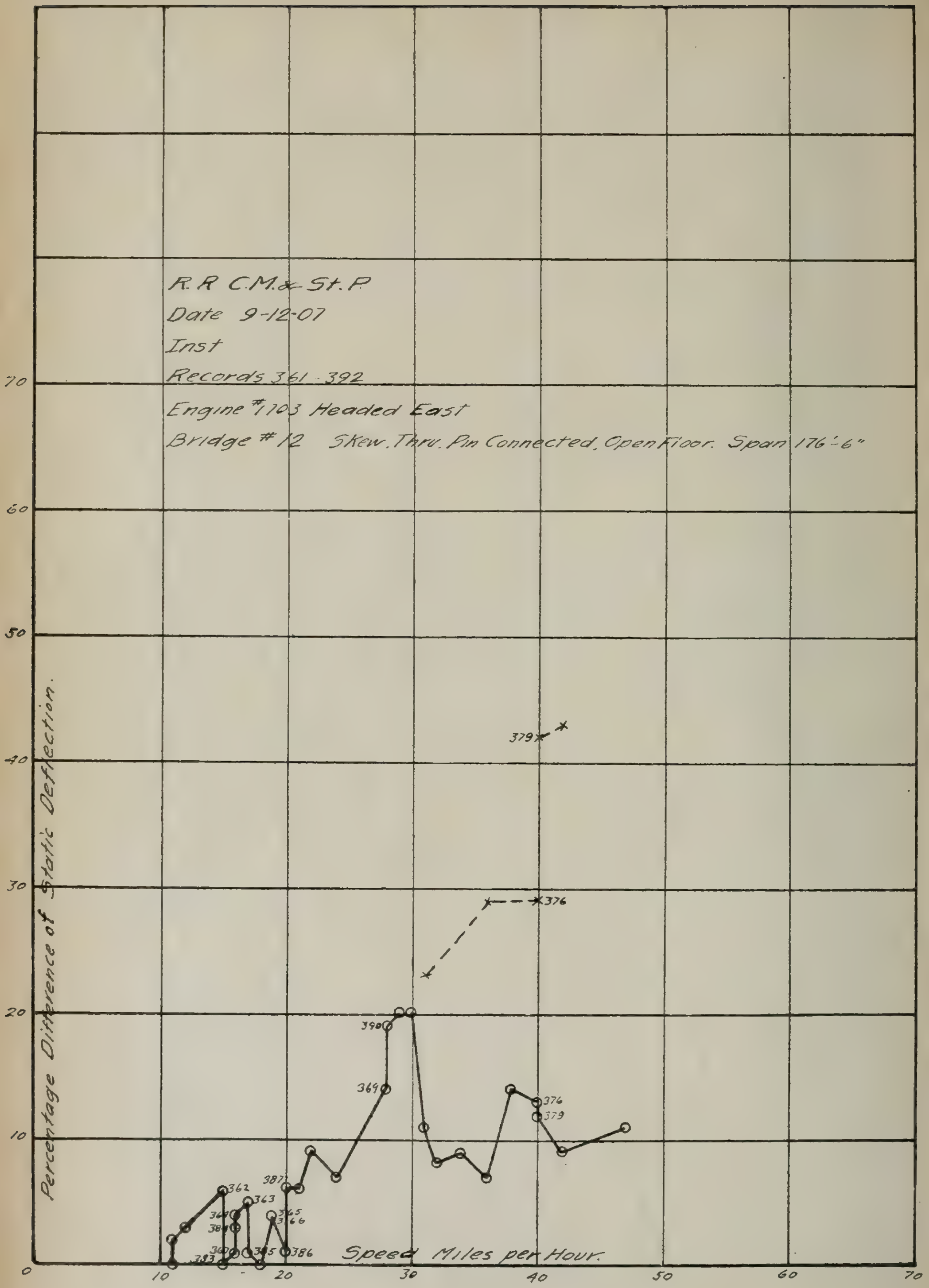
PLATE III—h.

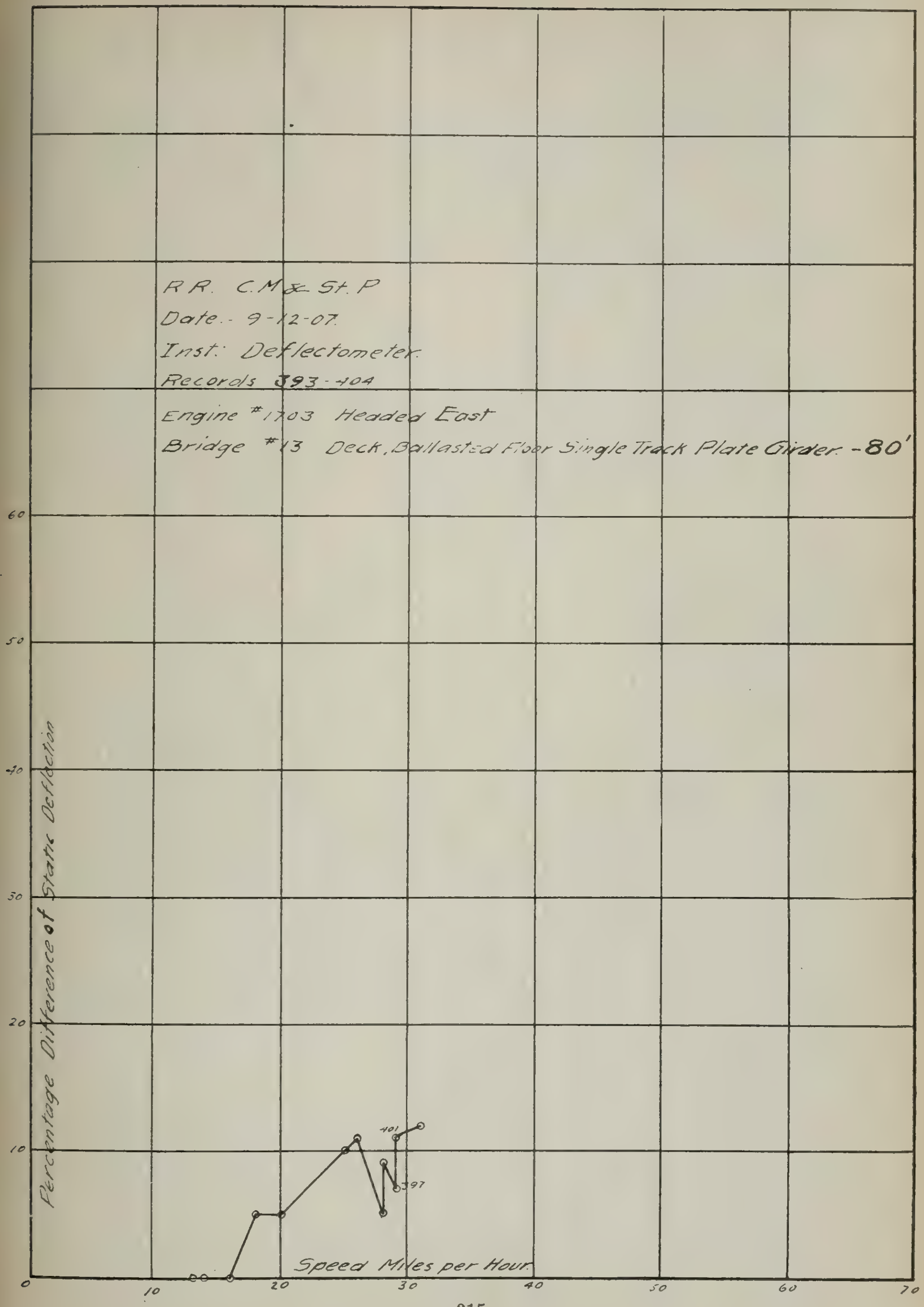

N
Counter Balance Feet from Center
S
Percentage Difference of Static Deflection.
Speed- Miles per Hour.
RR. C.B.&Q.
Date 9-7-07.
Inst. Deflectometer.
Records 235-264.
Engine 2523. Headed North.
Bridge 9. 132' Through Pin-Connected, Open Floor.
238
258
237
260
263
244
248
247
262
261
250
237
260
261
262
258
238
248
247
243
244
263
10
5
0
5
10
60
50
40
30
20
10
0
10
20
30
40
50
60
70


N
Counter Balance
Feet from Center.
10
5
0
5
10
S
70
60
50
40
30
20
10
0
R.R. C.B.&Q.
Date 9-9-07.
Inst. Deflectometer.
Records 265-301.
Engine 1919. Headed North.
Bridge 9. 132' Through Pin Connected Open Floor.
Percentage Difference of
Static Deflection.
Speed - Miles per Hour.
10
20
30
40
50
60
70
296
267
268
295
269
270
274
275
286
288
300
289
299
277
287-300
287
300-288
283
282
296
267
268
295
269
270
274
288
286
299
289

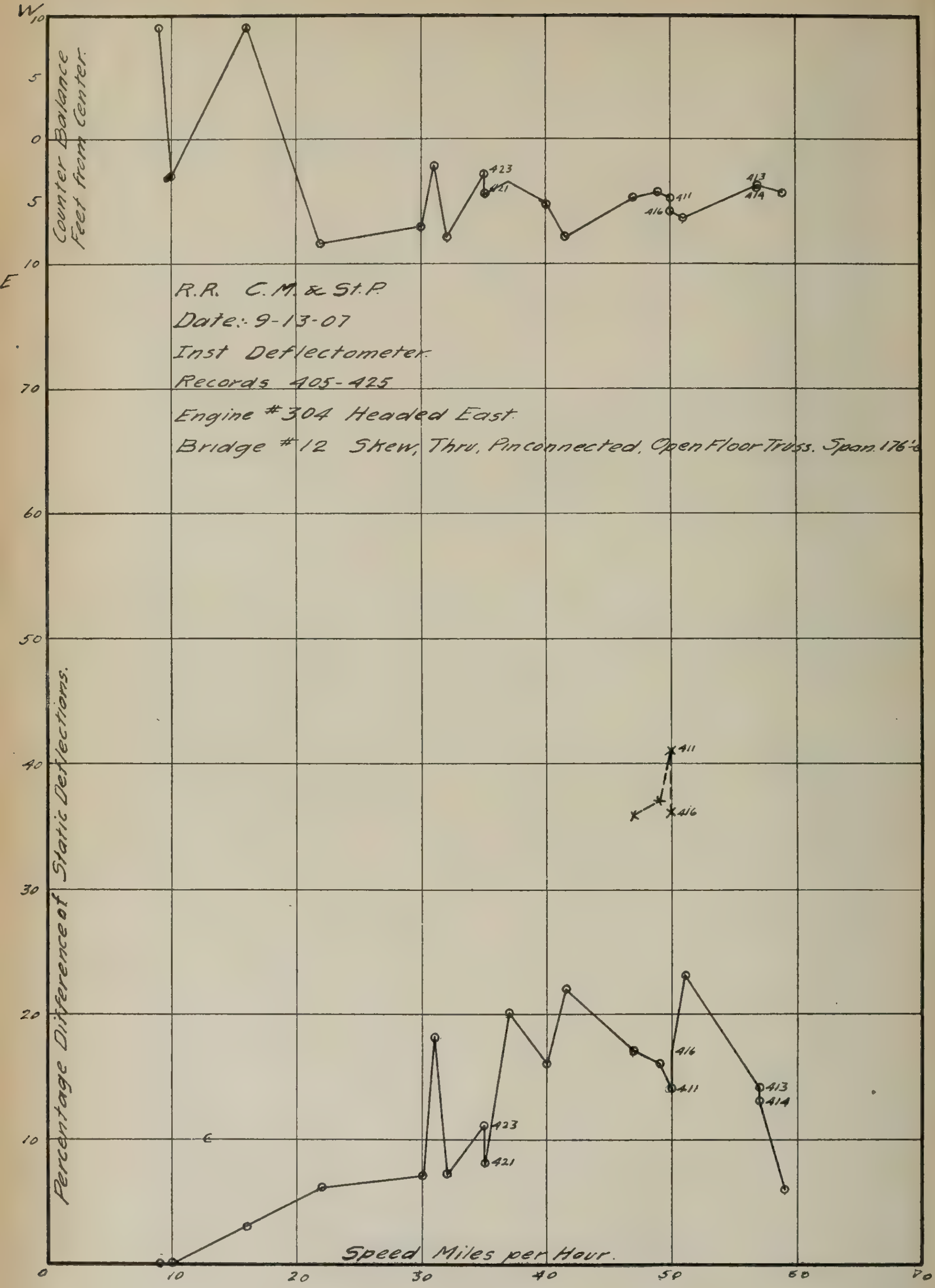

W
E
Counter Balance. Feet from Center.
10
5
0
5
10
305
313
312
319
321
R.R. – C.B. & Q.
Date – 9-10-07
Inst – Deflec.
Records 302 – 324
Engine – #2123 Headed East.
Bridge – #11 - Double Track - Skew - Thru. Plate Girder - 63' Span
Percentage Difference of Static Deflection
70
60
50
40
30
20
10
0
305
304
313
312
316
319
321
Speed Miles per Hour.
0
10
20
30
40
50
60
70

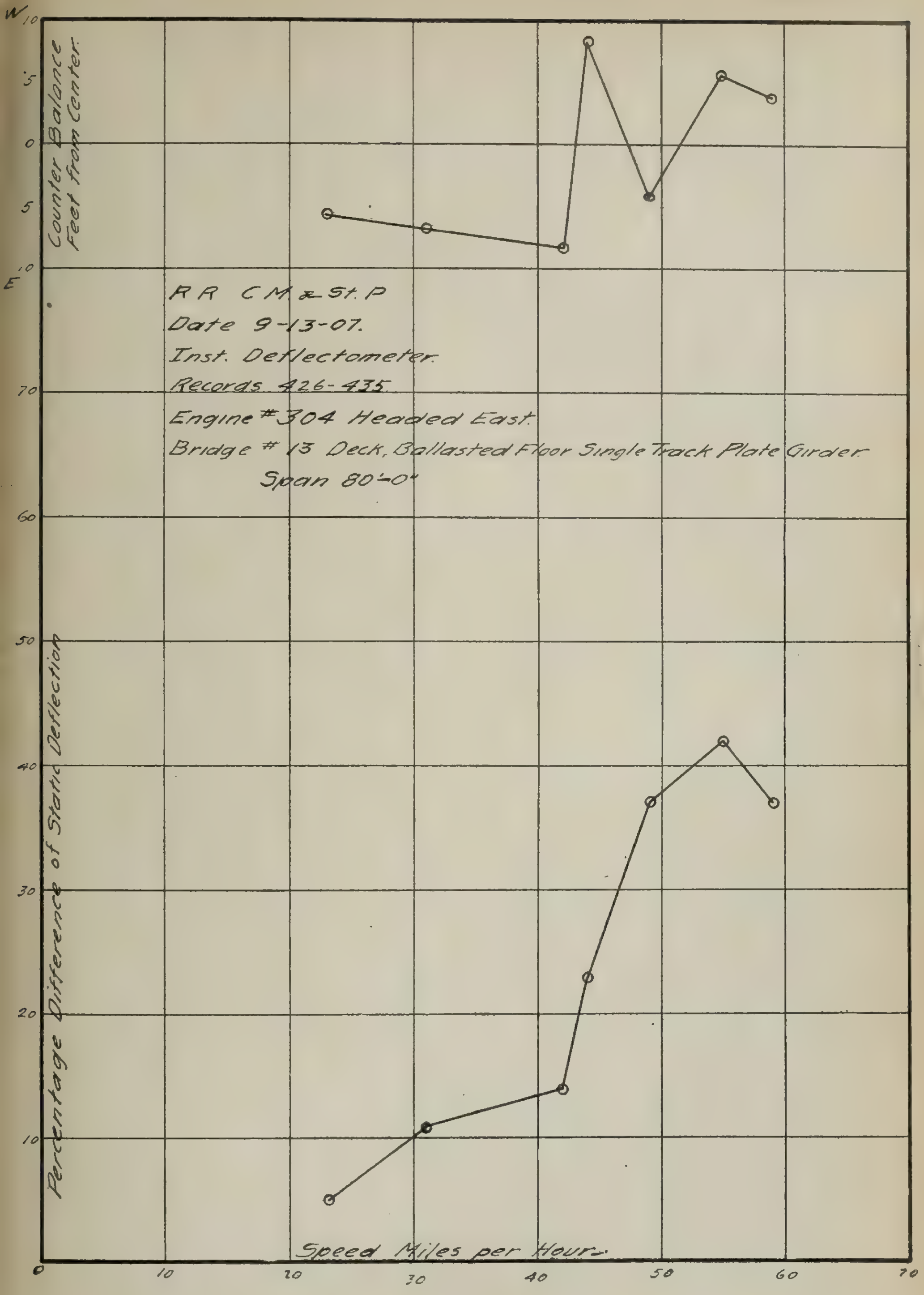

R.R. C.B.&Q
Date:- 9-11-07.
Inst. Deflectometer.
Records 325-360
Engine #2123. Headed East.
Bridge #11 Double Track, Thru. Open Floor Plate Girder Span 63'-0"
Counter Balance Feet from Center.
Percentage Difference of Static Deflection.
Speed Miles per Hour.
W
E
10
5
0
5
10
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
331
330
349
348
347
329
346
351
334
350
332
335
356
353
355
354
342
360
347
330
331
348
349
322
346
350
334
351
352
335
353
336
354
355
360
342


R.R C.M.& St.P.
Date 9-12-07
Inst
Records 361 - 392
Engine #7103 Headed East
Bridge #12 Skew. Thru. Pin Connected, Open Floor. Span 176'-6"
Percentage Difference of Static Deflection.
Speed Miles per Hour.
0
10
20
30
40
50
60
70
379
376
390
369
376
379
387
362
363
364
384
365
366
385
386
383

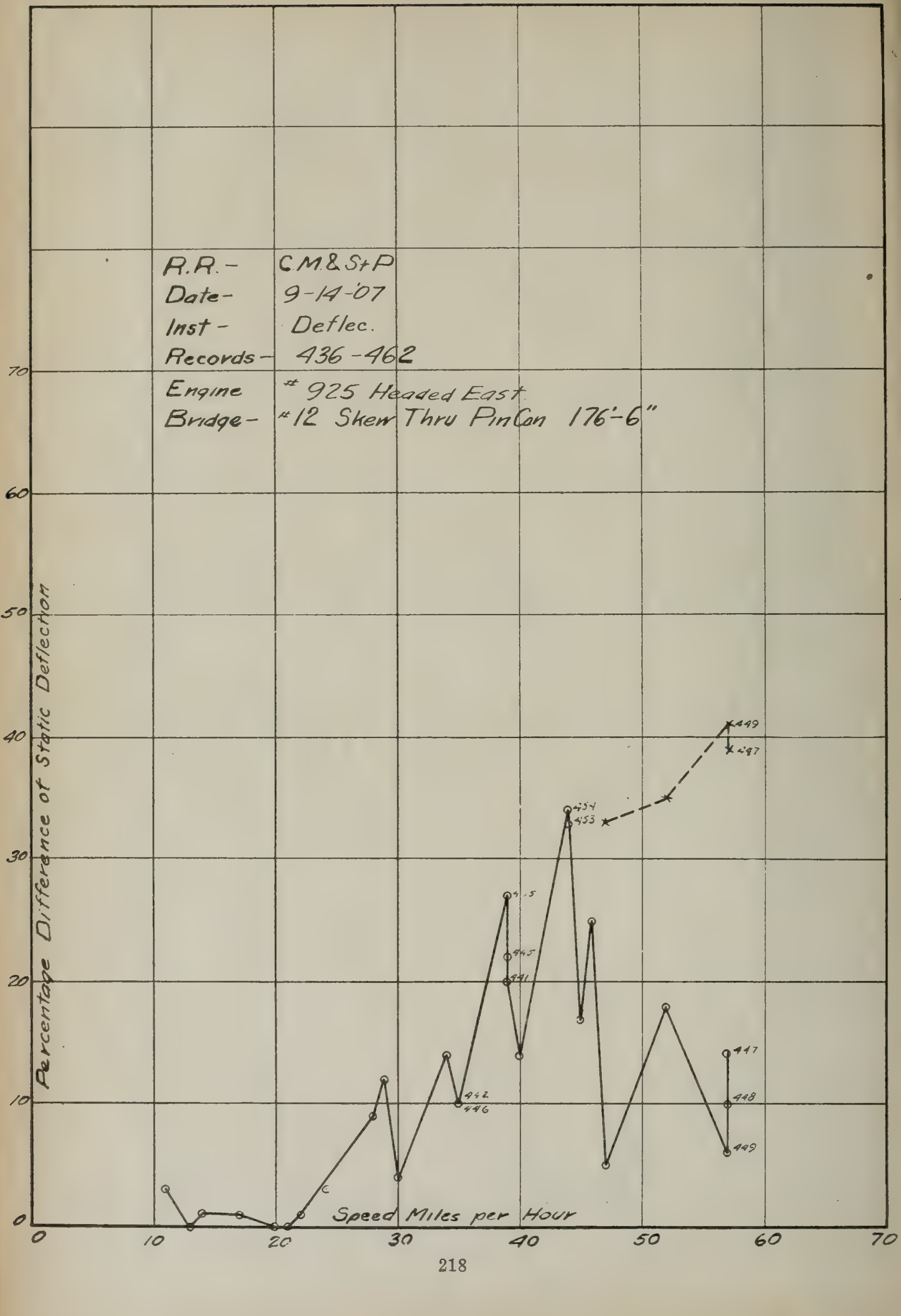


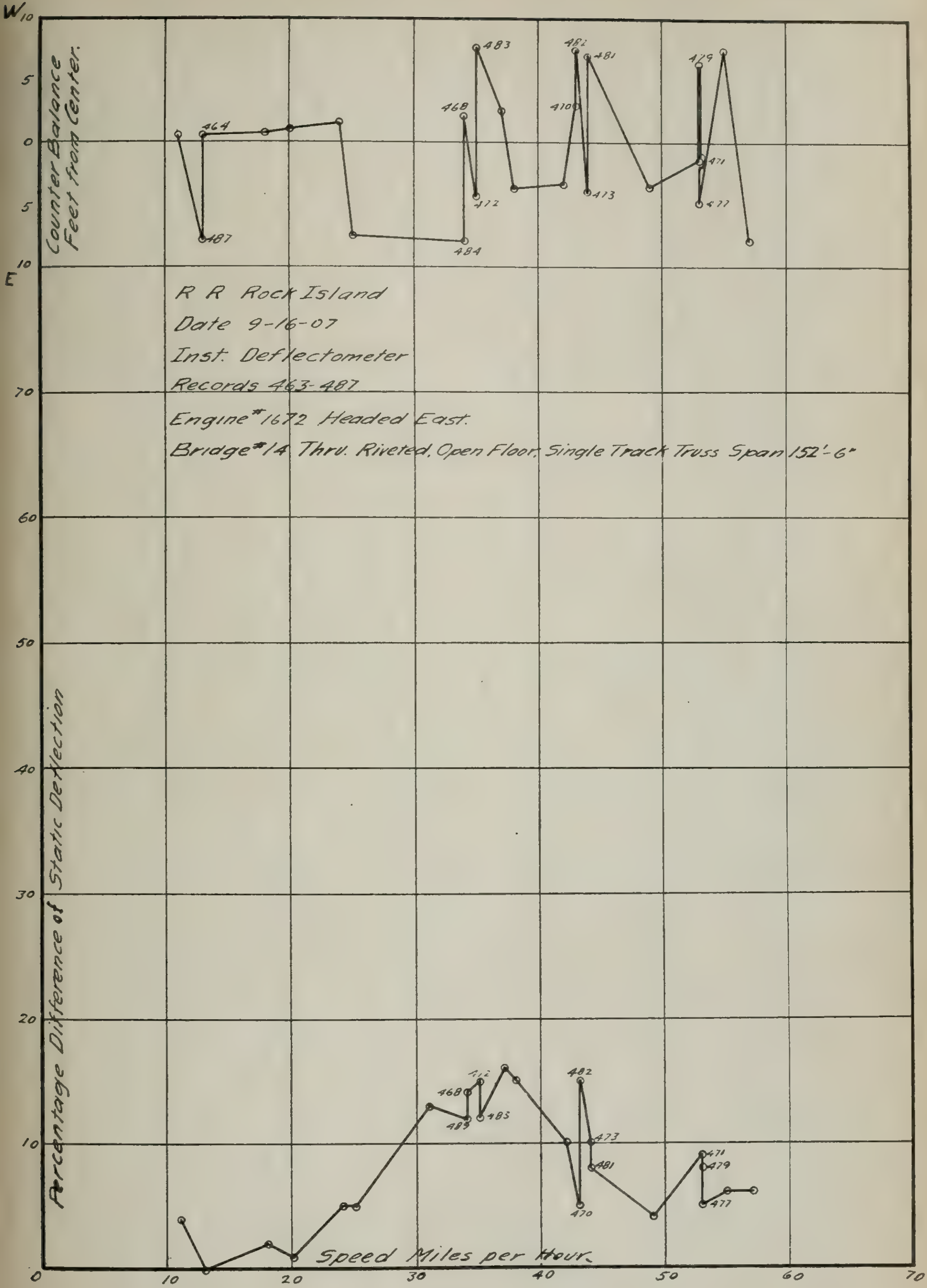
R.R. C.M.& St. P
Date.- 9-12-07.
Inst: Deflectometer.
Records 393-404
Engine #1703 Headed East
Bridge #13 Deck, Ballasted Floor Single Track Plate Girder. -80′

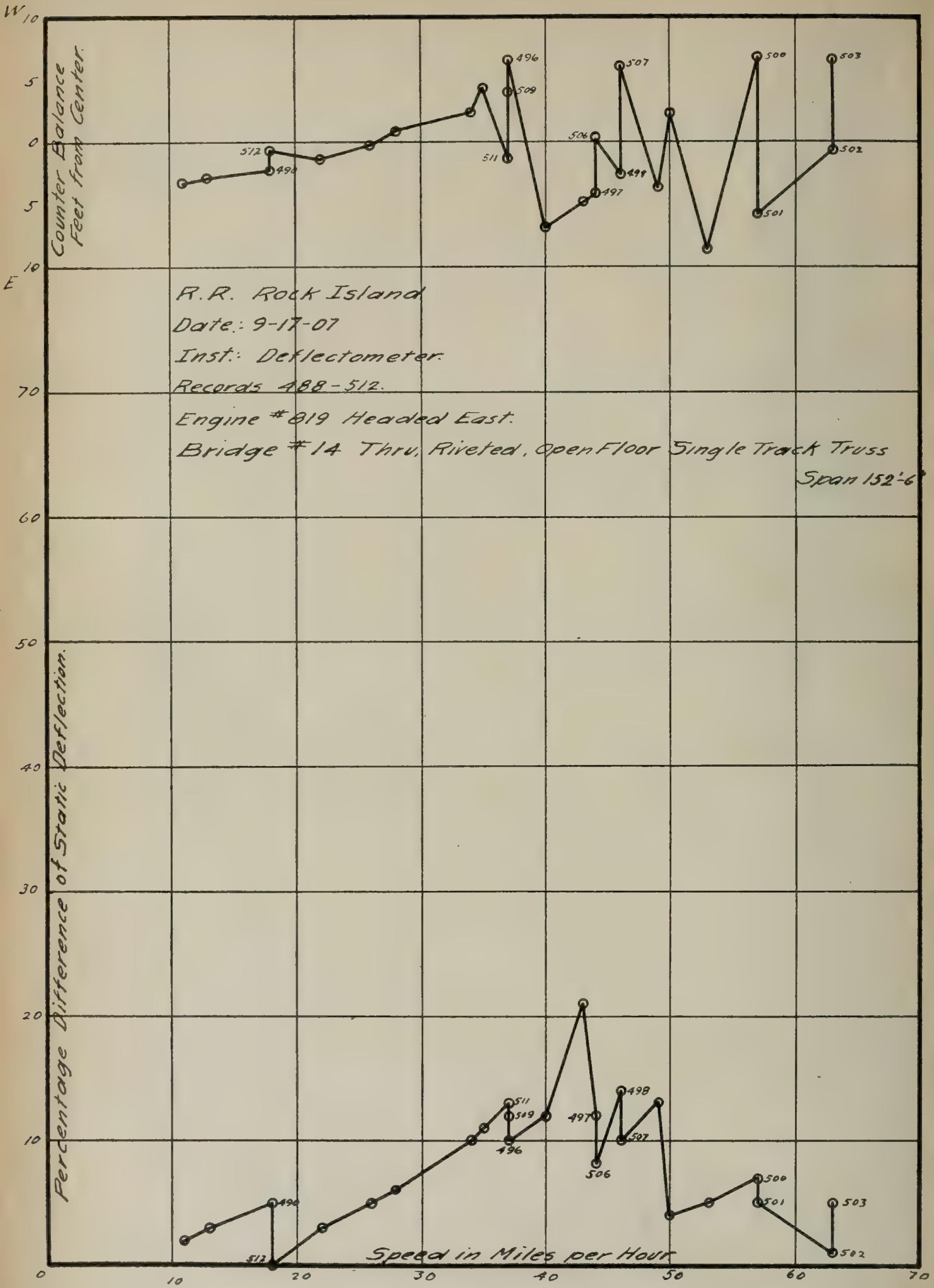

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
R.R. C.M. & St.P.
Date:- 9-13-07
Inst Deflectometer.
Records 405-425
Engine #304 Headed East.
Bridge #12 Skew, Thru, Pinconnected, Open Floor Truss. Span. 176'-
70
60
50
40
30
20
10
Percentage Difference of Static Deflections.
423
421
411
416
413
414
E
Speed Miles per Hour.
0
10
20
30
40
50
60
70



R R C M & St. P
Date 9-13-07.
Inst. Deflectometer.
Records 426-435
Engine # 304 Headed East.
Bridge # 13 Deck, Ballasted Floor Single Track Plate Girder.
Span 80'-0"


R.R.- C.M.&St.P
Date- 9-14-'07
Inst- Deflec.
Records- 436-462
Engine #925 Headed East
Bridge- #12 Skew Thru PinCon 176'-6"
Percentage Difference of Static Deflection
Speed Miles per Hour
0
10
20
30
40
50
60
70
449
487
454
453
445
441
442
446
447
448
449


W
E
Counter Balance Feet from Center.
10
5
0
5
10
R R Rock Island
Date 9-16-07
Inst. Deflectometer
Records 463-487
Engine #1672 Headed East.
Bridge #14 Thru. Riveted, Open Floor, Single Track Truss Span 152'-6"
464
487
468
484
483
472
482
410
481
473
479
471
477
Percentage Difference of Static Deflection
70
60
50
40
30
20
10
0
468
412
485
483
482
473
471
481
479
470
477
Speed Miles per Hour.
10
20
30
40
50
60
70


W
10
5
0
5
10
E
Counter Balance
Feet from Center.
496
509
511
512
490
506
507
498
497
500
501
503
502
R.R. Rock Island
Date.: 9-17-07
Inst.: Deflectometer.
Records 488-512.
Engine #819 Headed East.
Bridge #14 Thru, Riveted, Open Floor Single Track Truss
Span 152'-6"
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
490
512
511
509
496
497
498
507
506
500
501
503
502
Speed in Miles per Hour
10
20
30
40
50
60
70

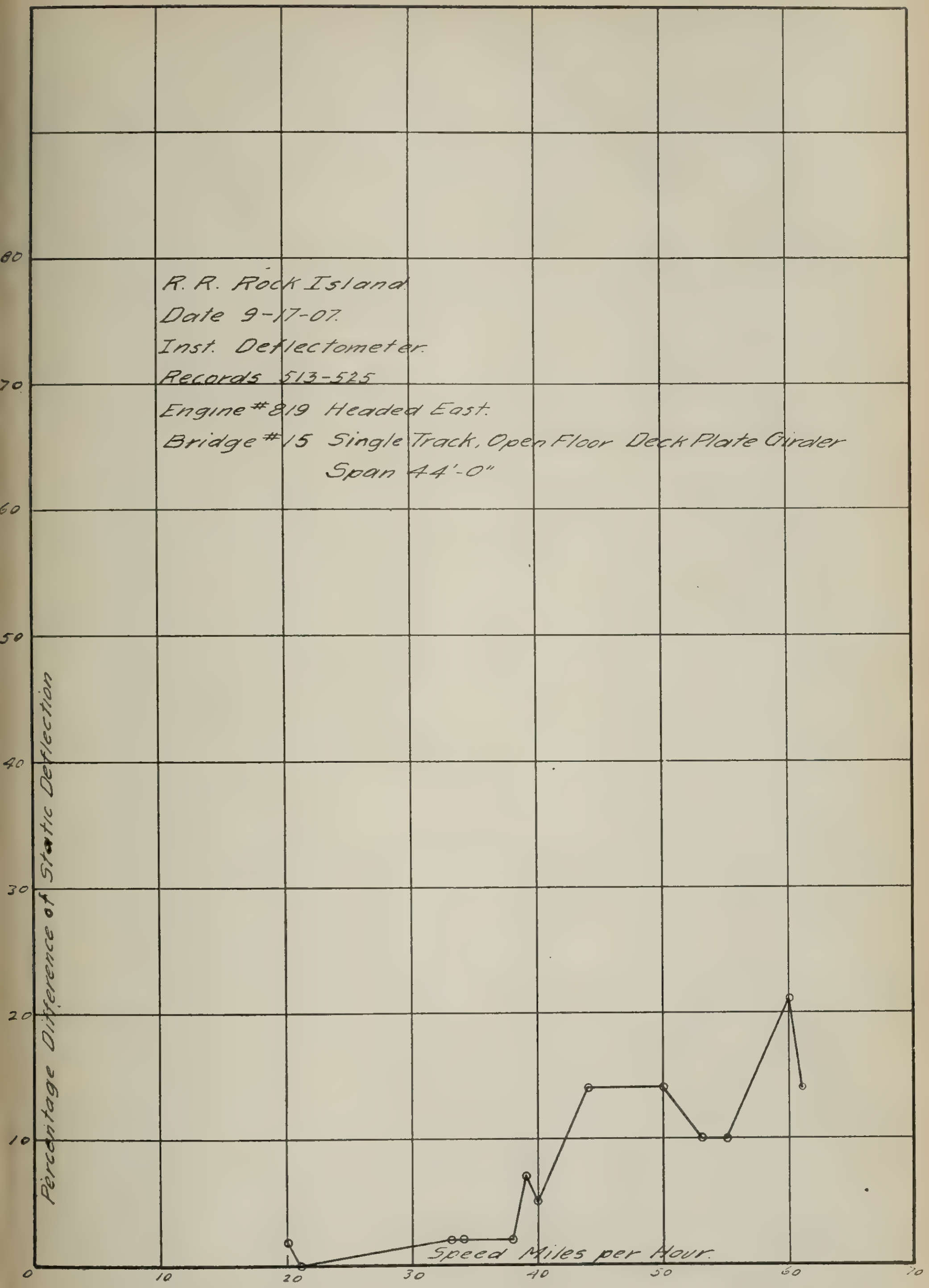
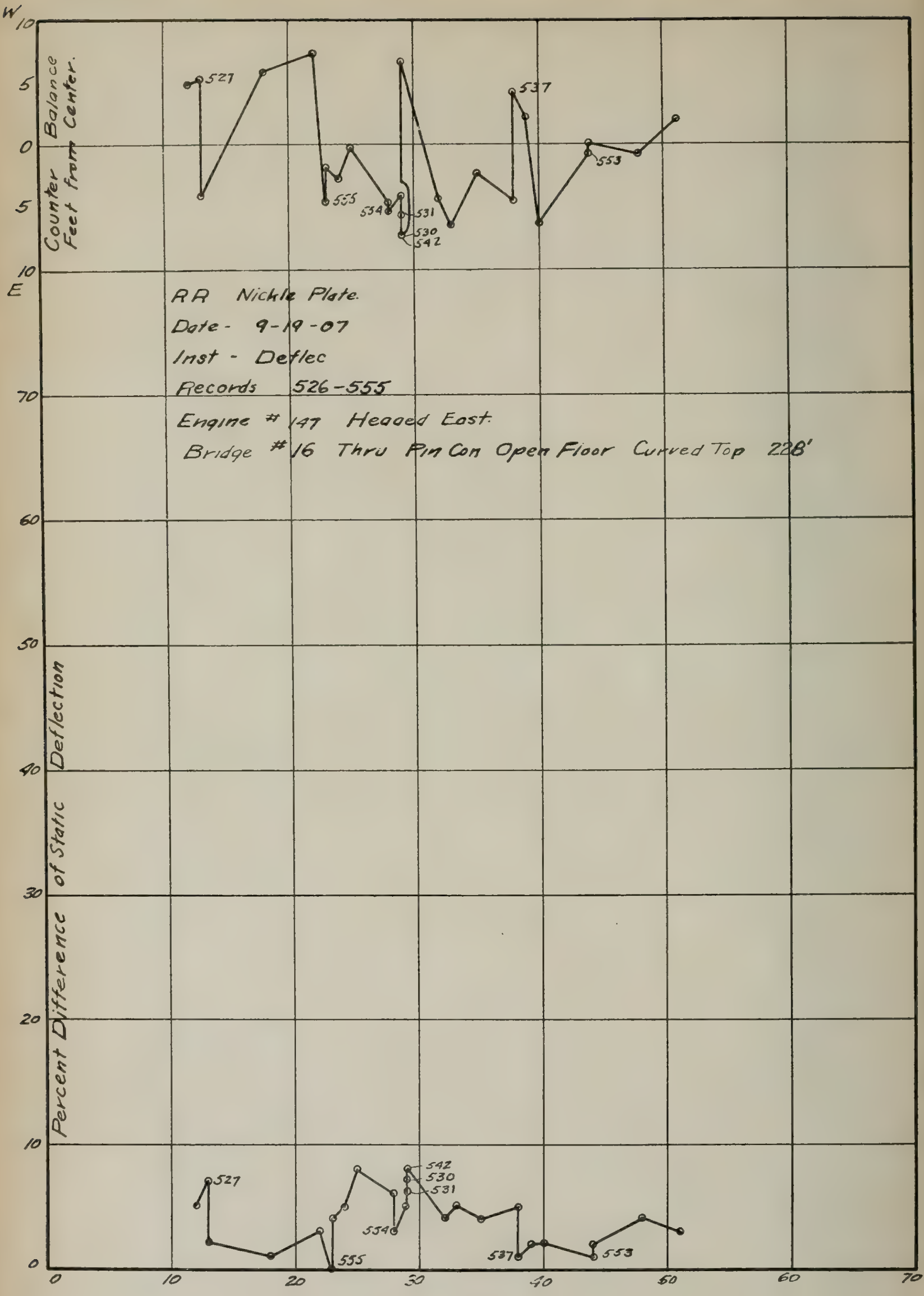
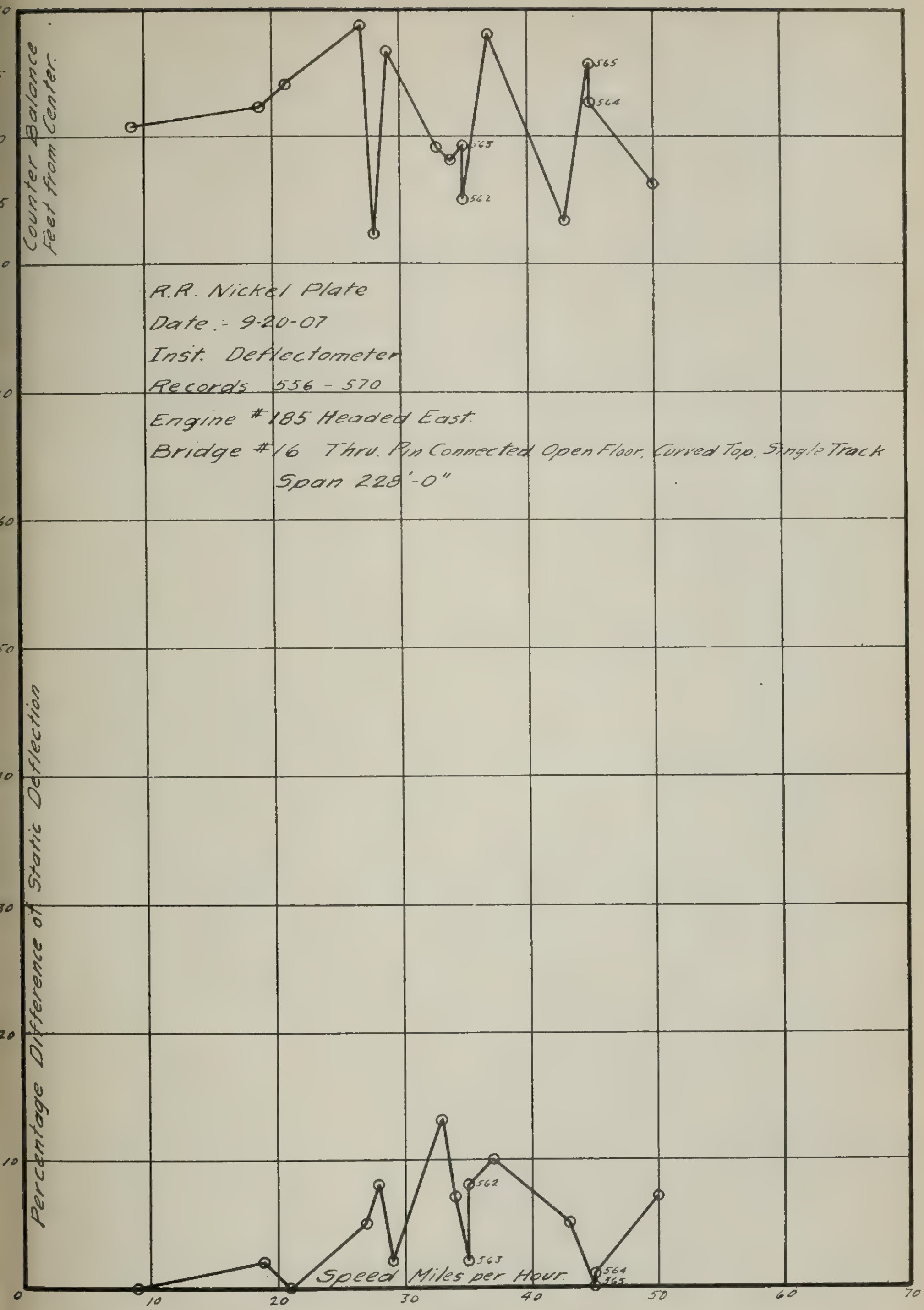
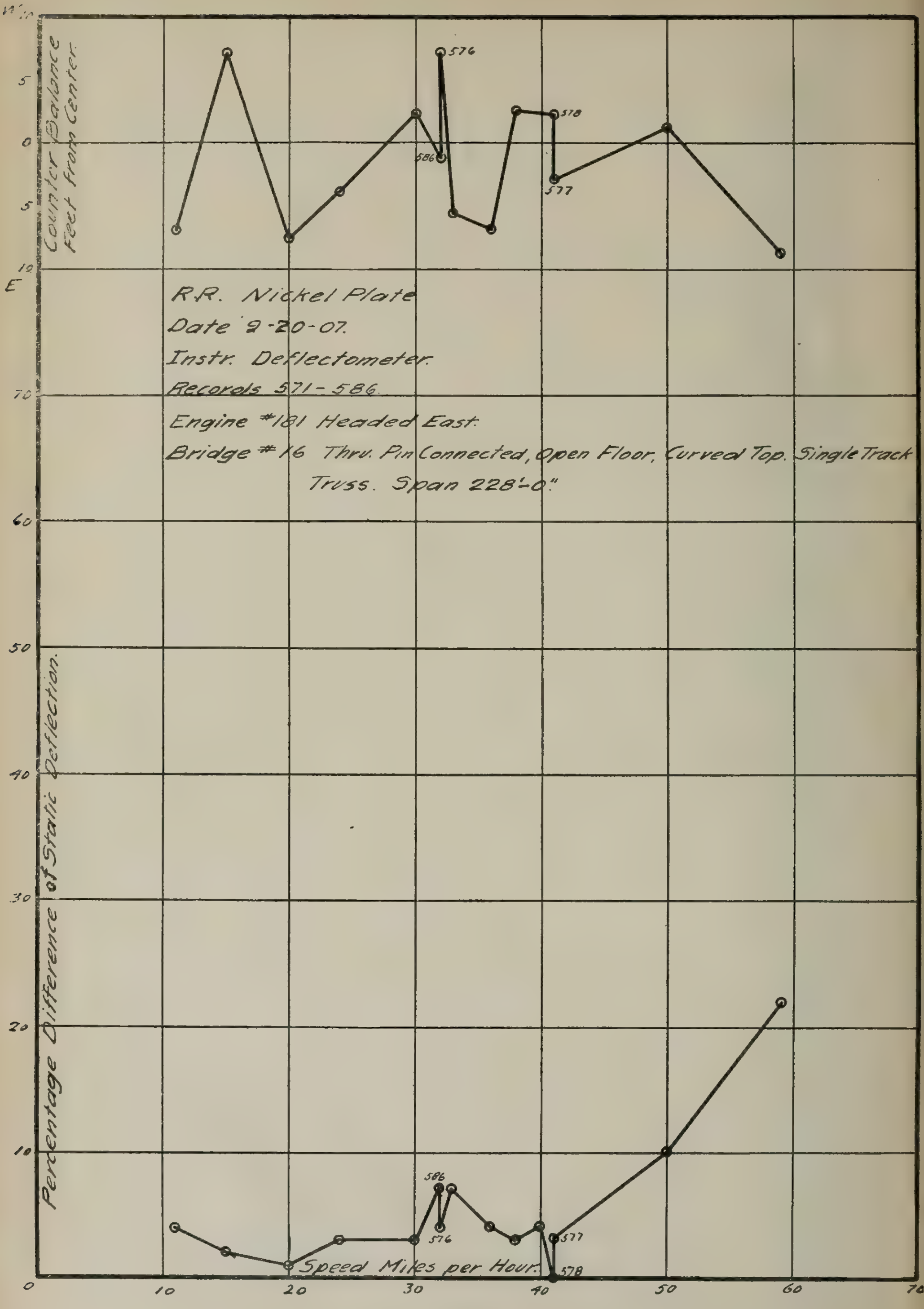

R. R. Rock Island.
Date 9-17-07.
Inst. Deflectometer.
Records 513-525
Engine #819 Headed East.
Bridge #15 Single Track, Open Floor Deck Plate Girder
Span 44'-0"
Percentage Difference of Static Deflection
Speed Miles per Hour.
0
10
20
30
40
50
60
70
80

PLATE III—t.

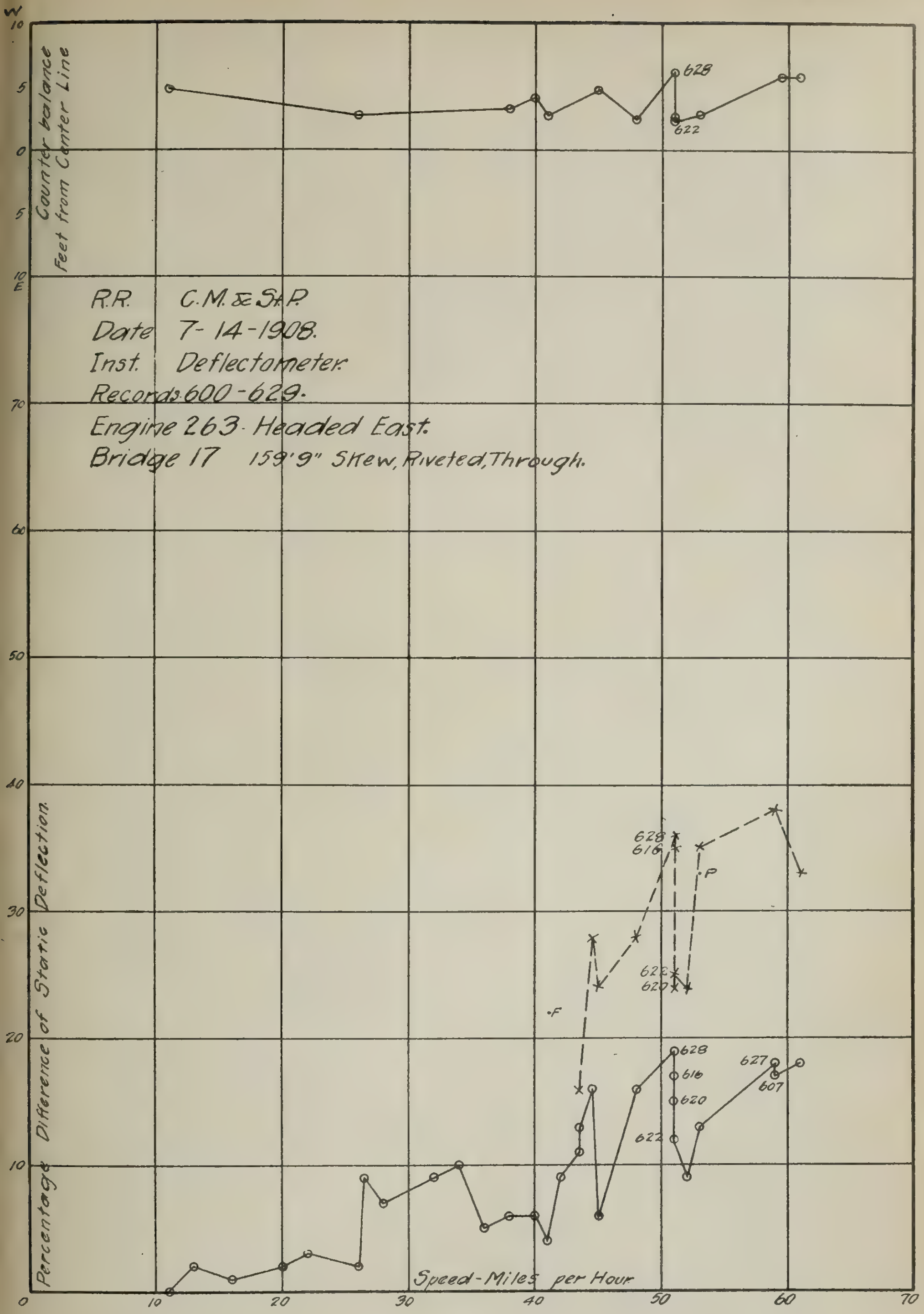


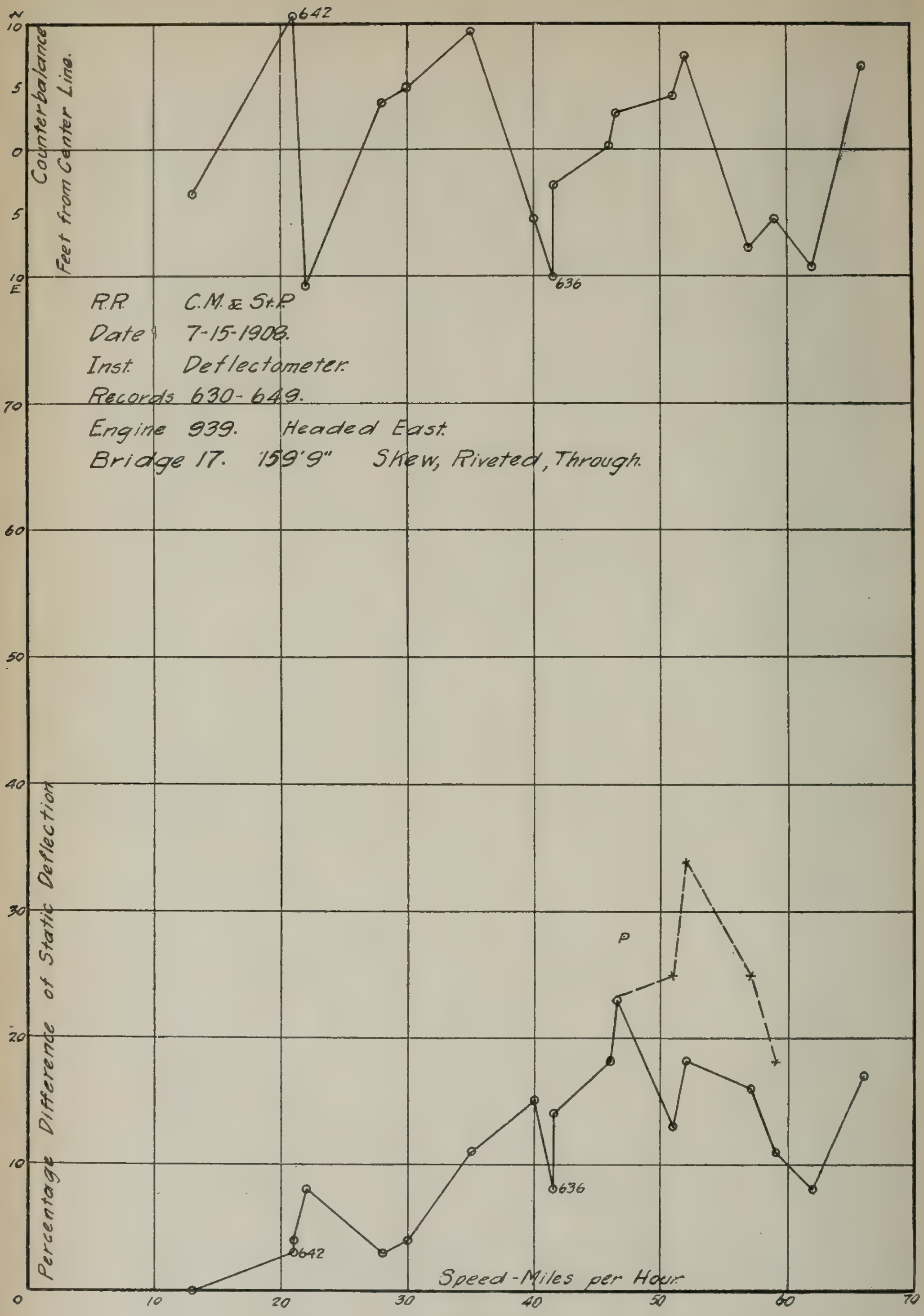
RR Nickle Plate.
Date - 9-19-07
Inst - Deflec
Records 526-555
Engine # 147 Headed East.
Bridge # 16 Thru Pin Con Open Floor Curved Top 228'


Counter Balance
Feet from Center.
R.R. Nickel Plate
Date.- 9-20-07
Inst. Deflectometer
Records 556 - 570
Engine #185 Headed East.
Bridge #16 Thru. Pin Connected Open Floor. Curved Top. Single Track
Span 228'-0"
565
564
563
562
Percentage Difference of Static Deflection
562
563
564
565
Speed Miles per Hour.
30
20
10
0
10
20
30
40
50
60
70



R.R. Nickel Plate
Date 9-20-07.
Instr. Deflectometer.
Records 571-586.
Engine #181 Headed East.
Bridge #16 Thru. Pin Connected, Open Floor, Curved Top. Single Track Truss. Span 228'-0".


W
Counter balance Feet from Center Line
10
5
0
5
10
E
R.R. C.M.&St.P.
Date 7-14-1908.
Inst. Deflectometer.
Records 600-629.
Engine 263. Headed East.
Bridge 17 159'9" Skew, Riveted, Through.
628
622
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
628
616
622
620
F
P
628
616
620
622
627
607
Speed-Miles per Hour
0
10
20
30
40
50
60
70



642
N
10
5
0
5
10
E
Counterbalance
Feet from Center Line.
636
R.R. C.M. & St.P.
Date 7-15-1908.
Inst. Deflectometer.
Records 630-649.
Engine 939. Headed East.
Bridge 17. 159'9" Skew, Riveted, Through.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
P
636
642
Speed-Miles per Hour.
10
20
30
40
50
60
70

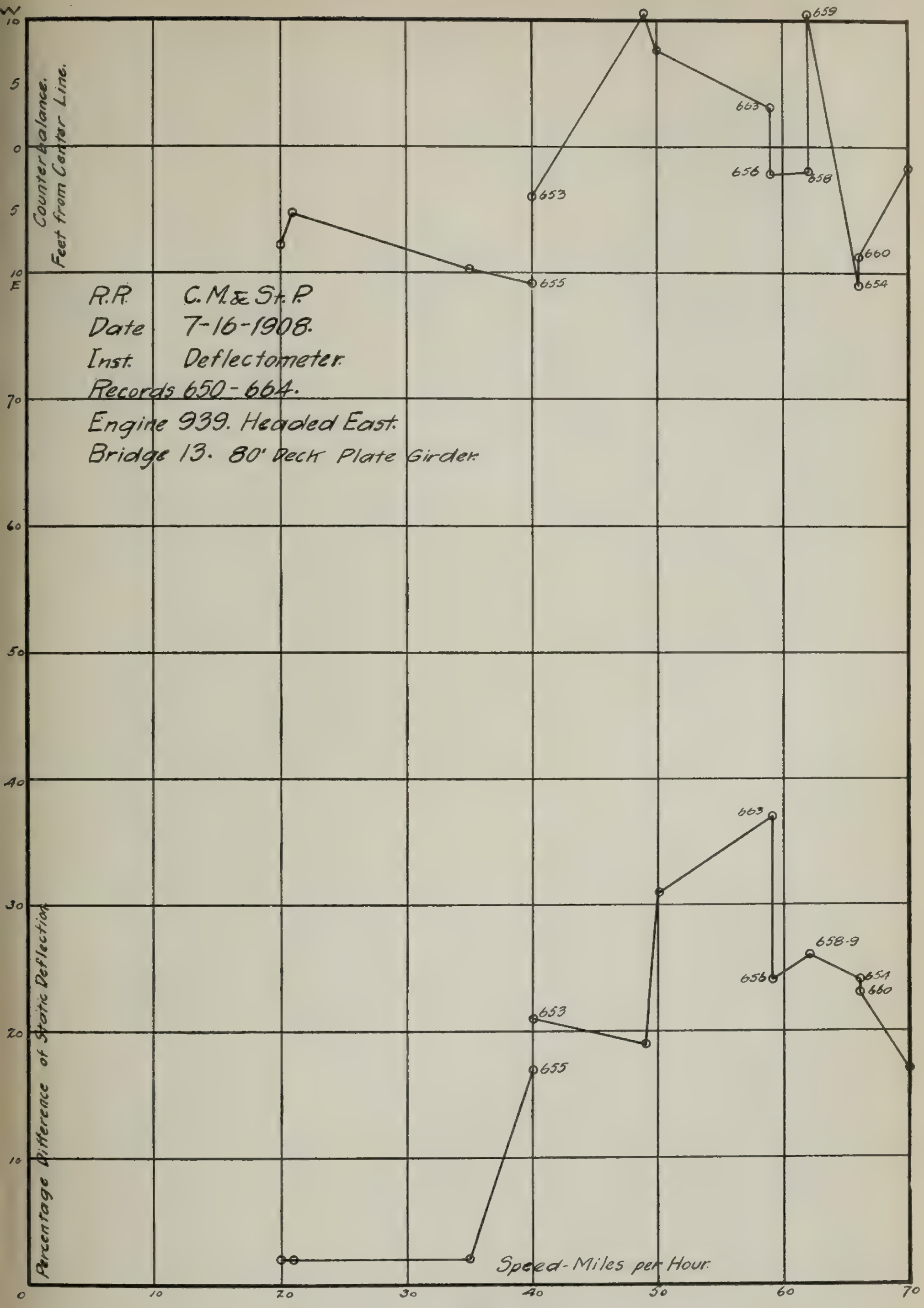
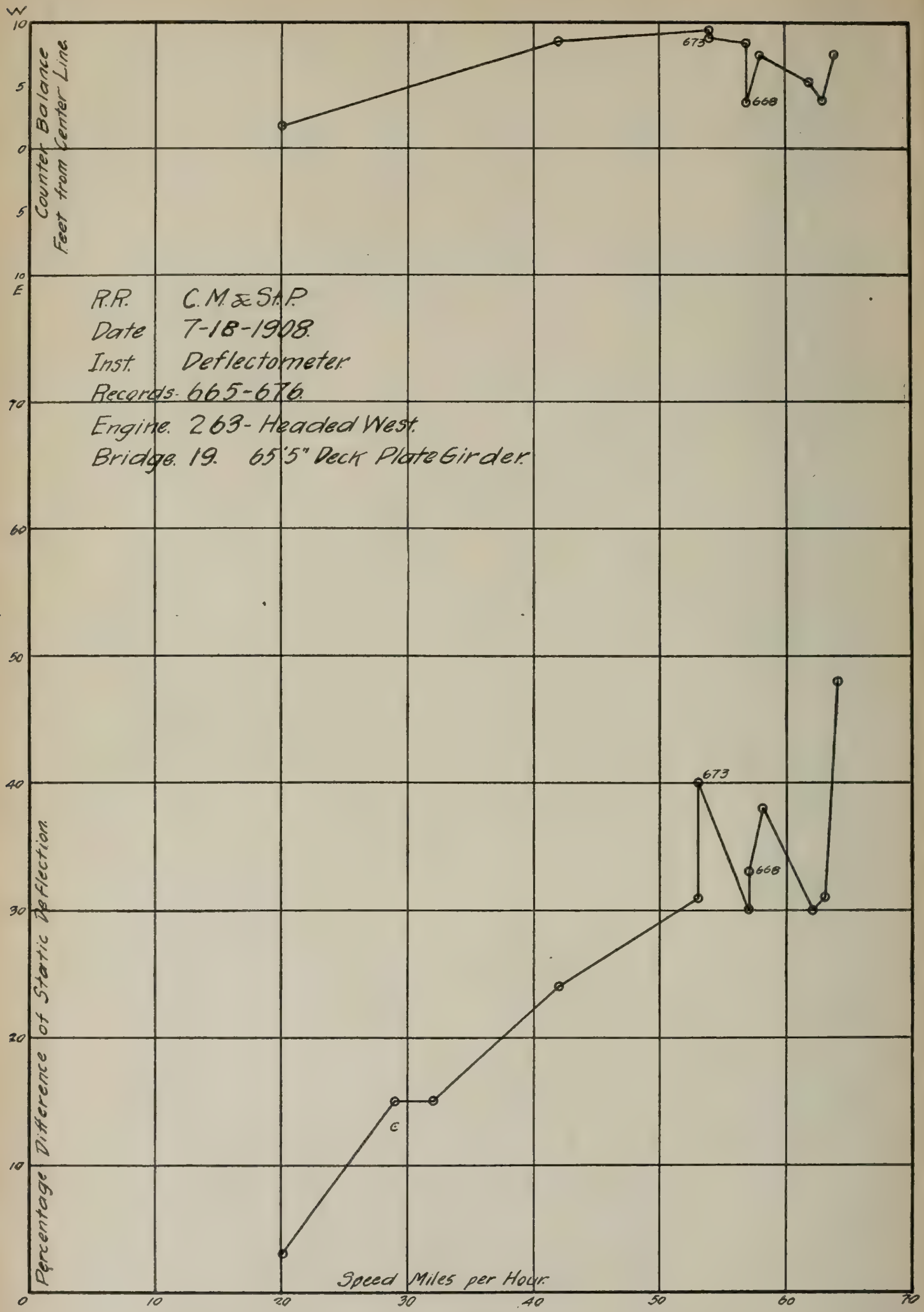

W
10
5
0
5
10
E
Counterbalance.
Feet from Center Line.
653
655
663
656
658
659
660
654
R.R. C.M.& St.P.
Date 7-16-1908.
Inst. Deflectometer.
Records 650-664.
Engine 939. Headed East.
Bridge 13. 80' Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
663
658-9
656
654
660
653
655
Speed-Miles per Hour.
0
10
20
30
40
50
60
70

PLATE III—z.


W
10
5
0
5
10
E
Counter Balance
Feet from Center Line
673
668
R.R. C.M.&St.P.
Date 7-18-1908.
Inst. Deflectometer.
Records. 665-676.
Engine. 263- Headed West.
Bridge. 19. 65'5" Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
673
668
c
Speed Miles per Hour.
10
20
30
40
50
60
70

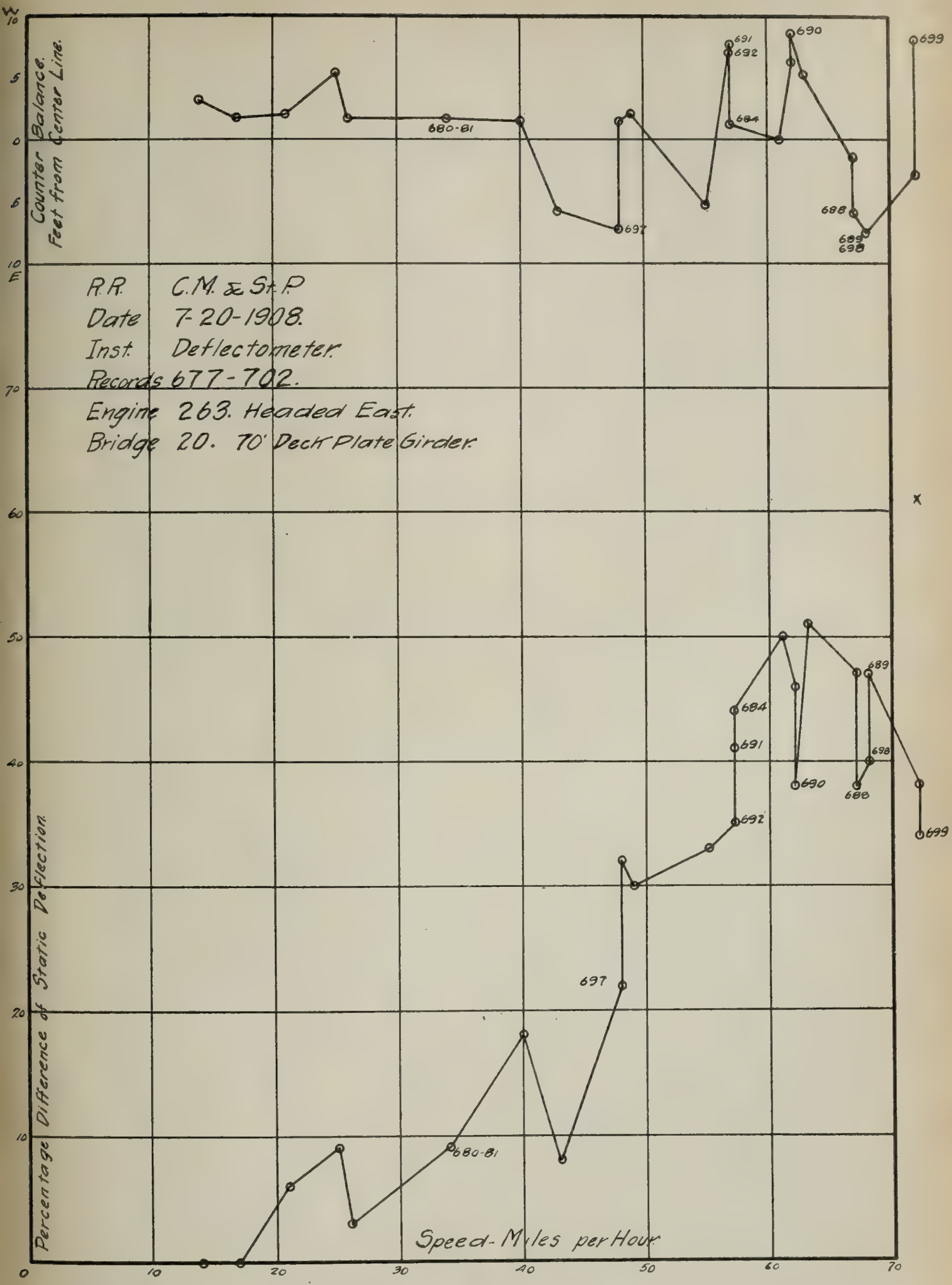
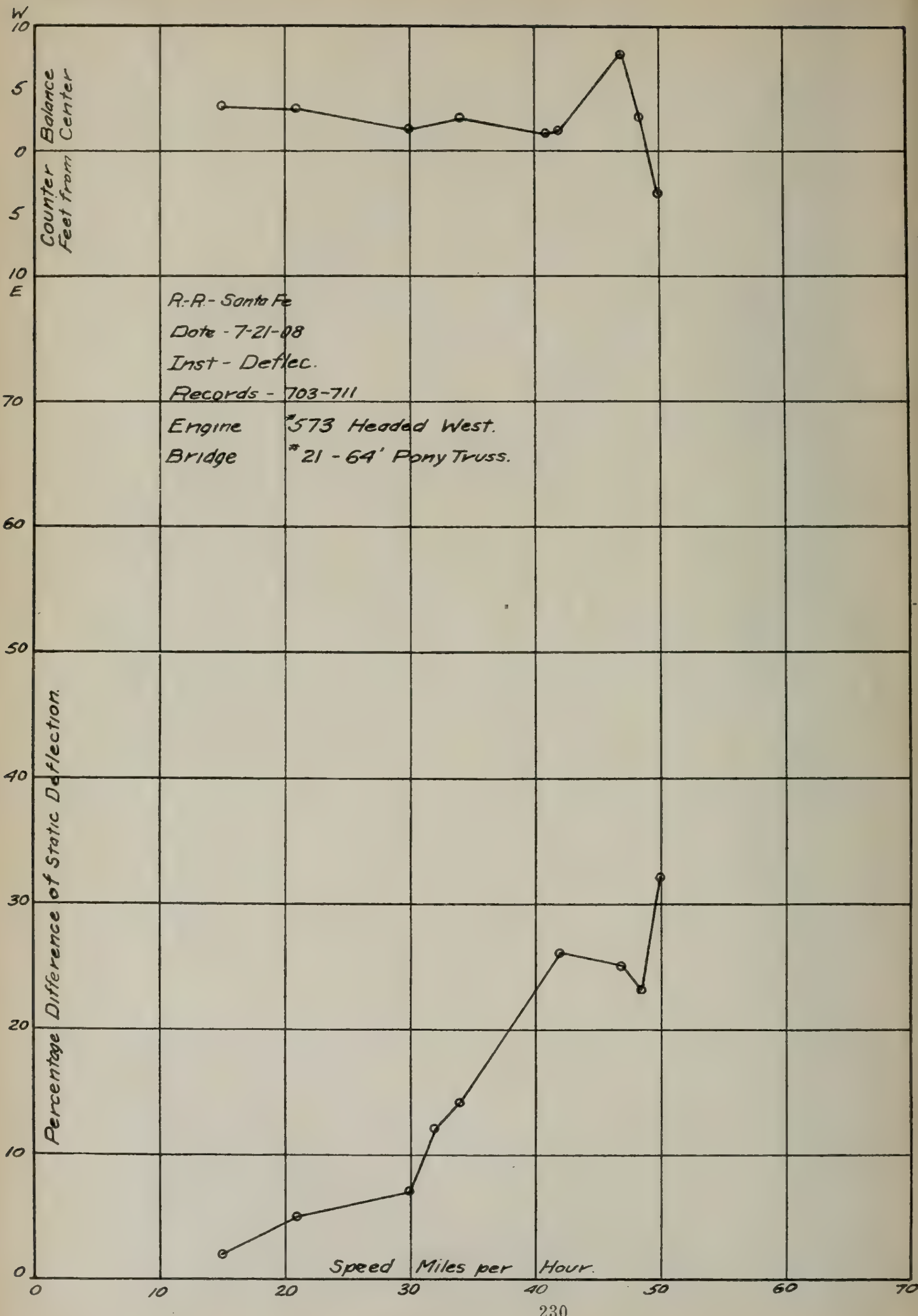

W
10
5
0
5
10
E
Counter Balance.
Feet from Center Line.
680-81
691
692
684
690
699
697
688
689
698
R.R. C.M. & St. P.
Date 7-20-1908.
Inst. Deflectometer.
Records 677-702.
Engine 263. Headed East.
Bridge 20. 70' Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
684
691
692
690
689
698
688
699
697
680-81
Speed-Miles per Hour
0
10
20
30
40
50
60
70

PLATE III—ab.


W
10
5
0
5
10
E
Counter Balance
Feet from Center
R.-R.- Santa Fe
Date - 7-21-08
Inst - Deflec.
Records - 703-711
Engine #573 Headed West.
Bridge #21 - 64' Pony Truss.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
Speed Miles per Hour.
0
10
20
30
40
50
60
70

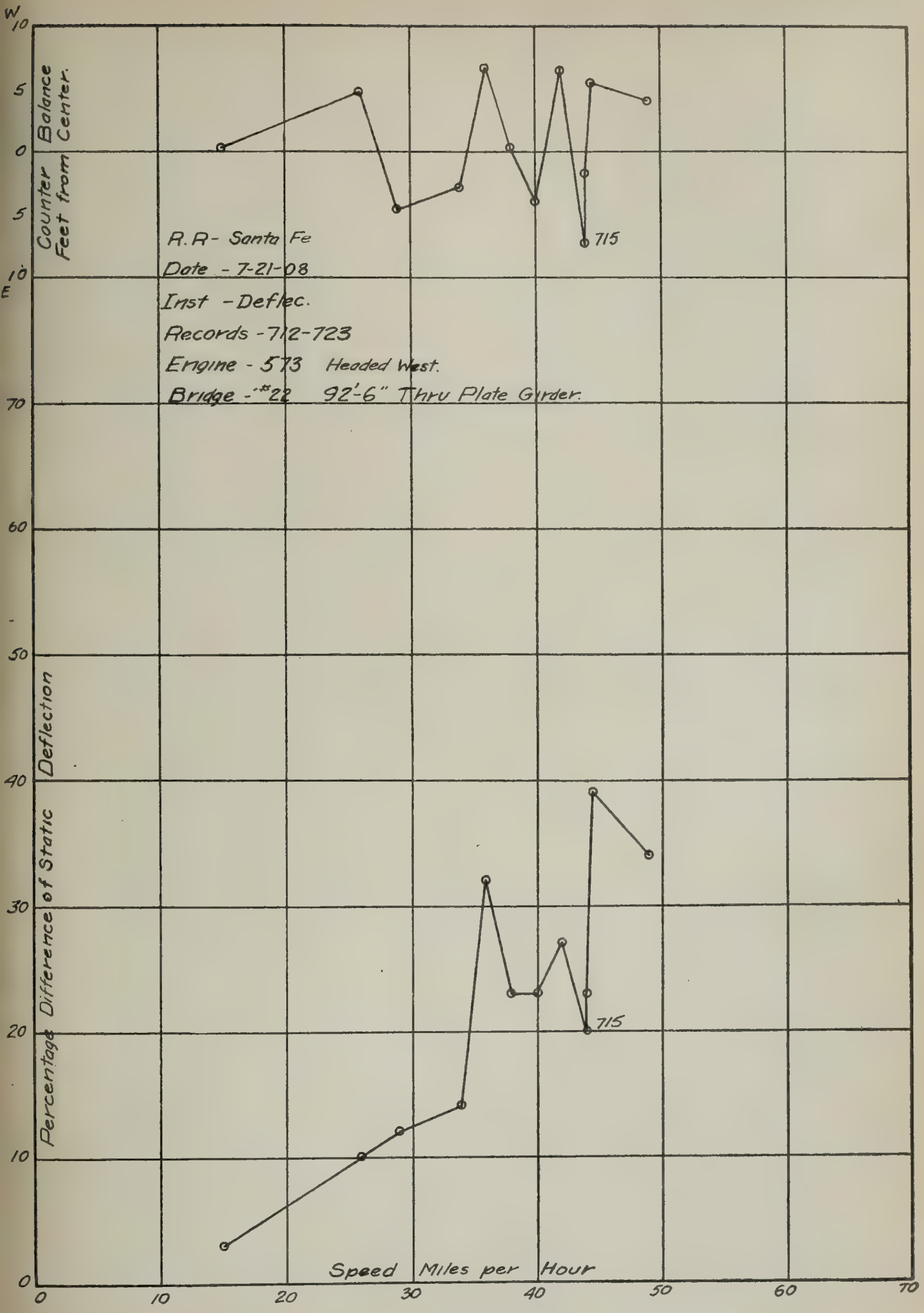
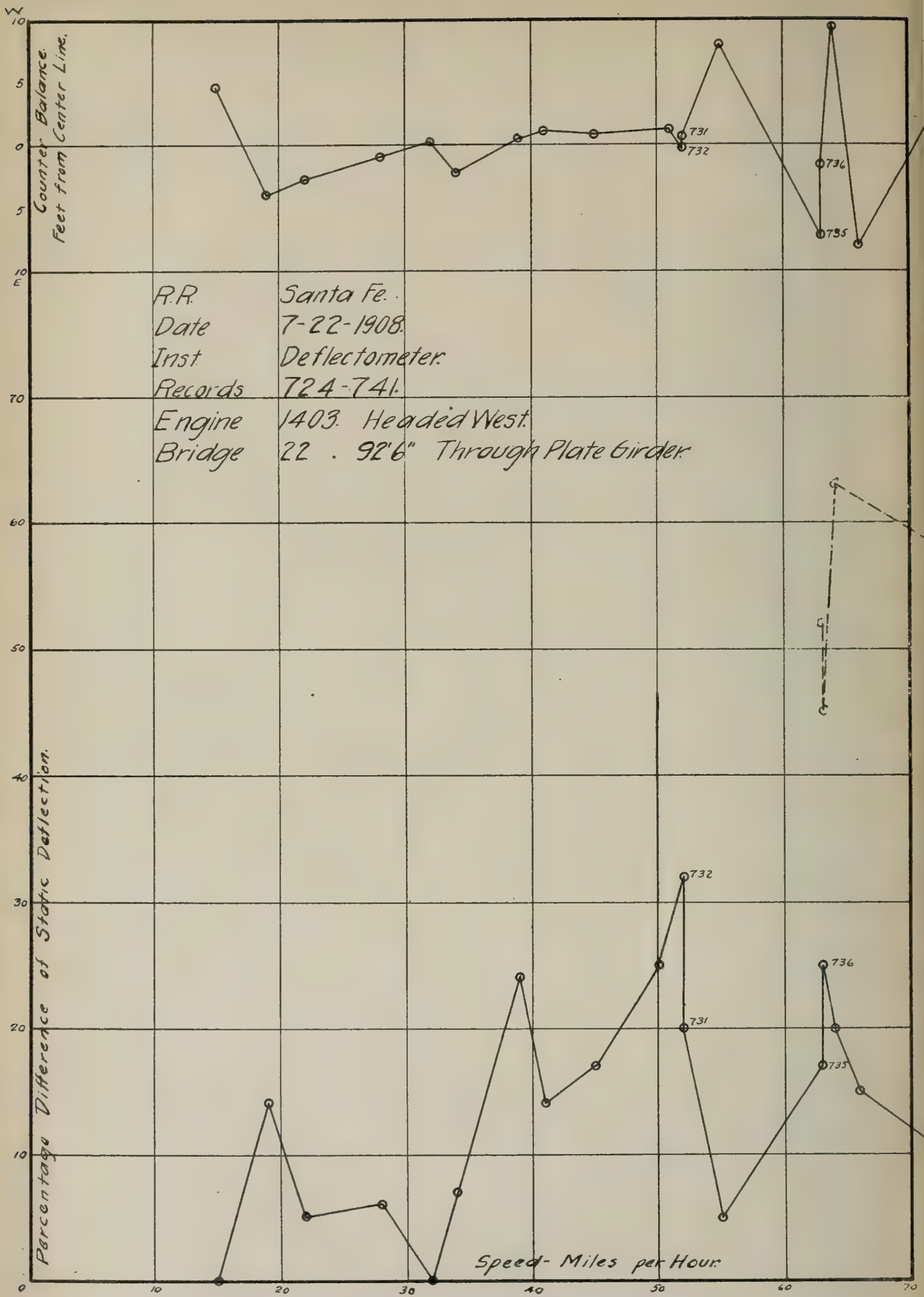
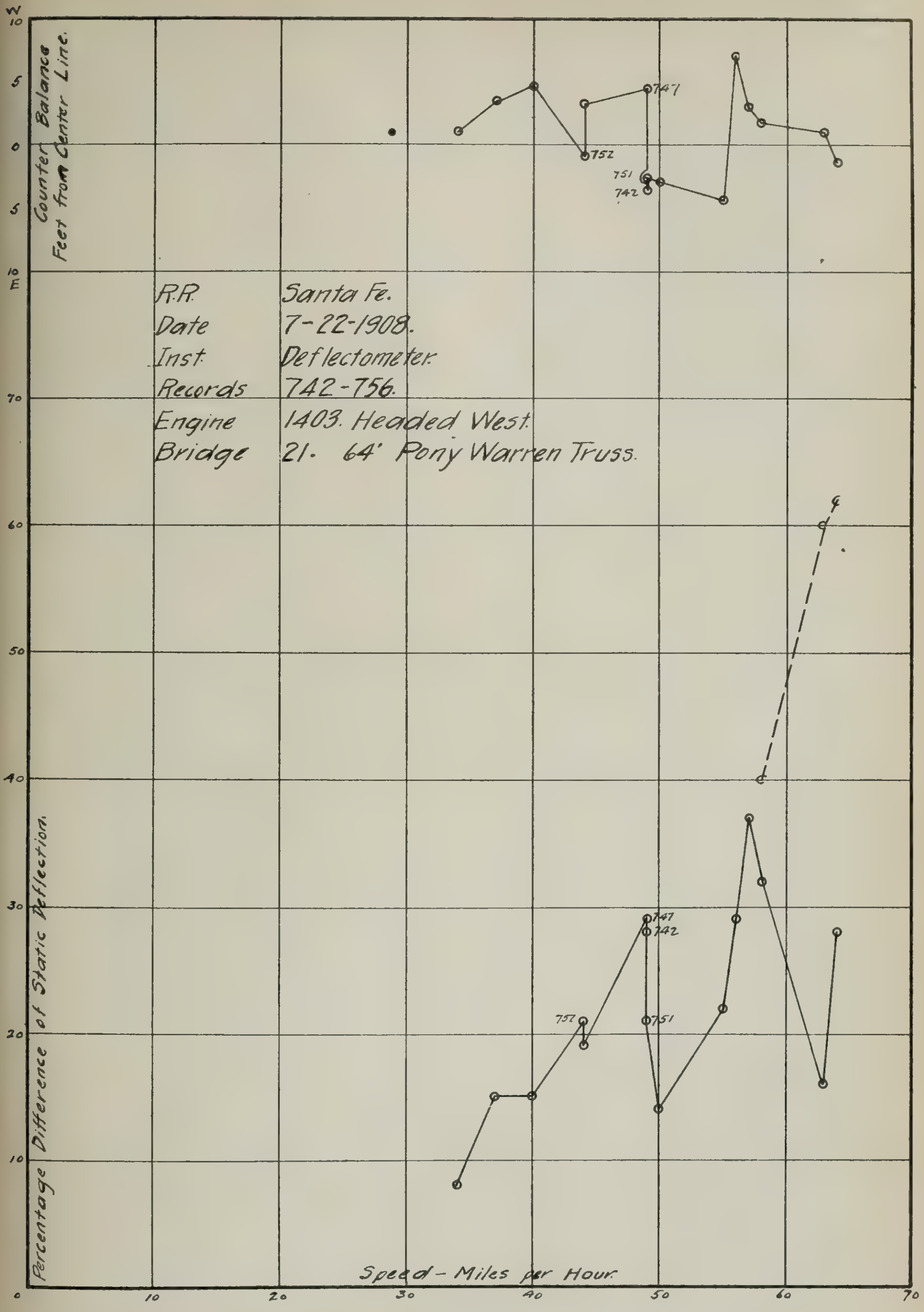

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
R.R- Santa Fe
Date - 7-21-08
Inst - Deflec.
Records - 712-723
Engine - 573 Headed West.
Bridge - #22 92'-6" Thru Plate Girder.
715
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
715
Speed Miles per Hour
0
10
20
30
40
50
60
70

PLATE III—ad.


W
10
5
0
5
10
E
Counter Balance.
Feet from Center Line.
731
732
736
735
R.R. Santa Fe.
Date 7-22-1908.
Inst. Deflectometer.
Records 724-741.
Engine 1403. Headed West.
Bridge 22 . 92'6" Through Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
732
736
731
735
Speed- Miles per Hour.
10
20
30
40
50
60
70


Counter Balance
Feet from Center Line.
W
10
5
0
5
10
E
R.R. Santa Fe.
Date 7-22-1908.
Inst. Deflectometer.
Records 742-756.
Engine 1403. Headed West.
Bridge 21. 64' Pony Warren Truss.
747
752
751
742
747
742
752
751
Percentage Difference of Static Deflection.
70
60
50
40
30
20
10
0
Speed - Miles per Hour.
10
20
30
40
50
60
70

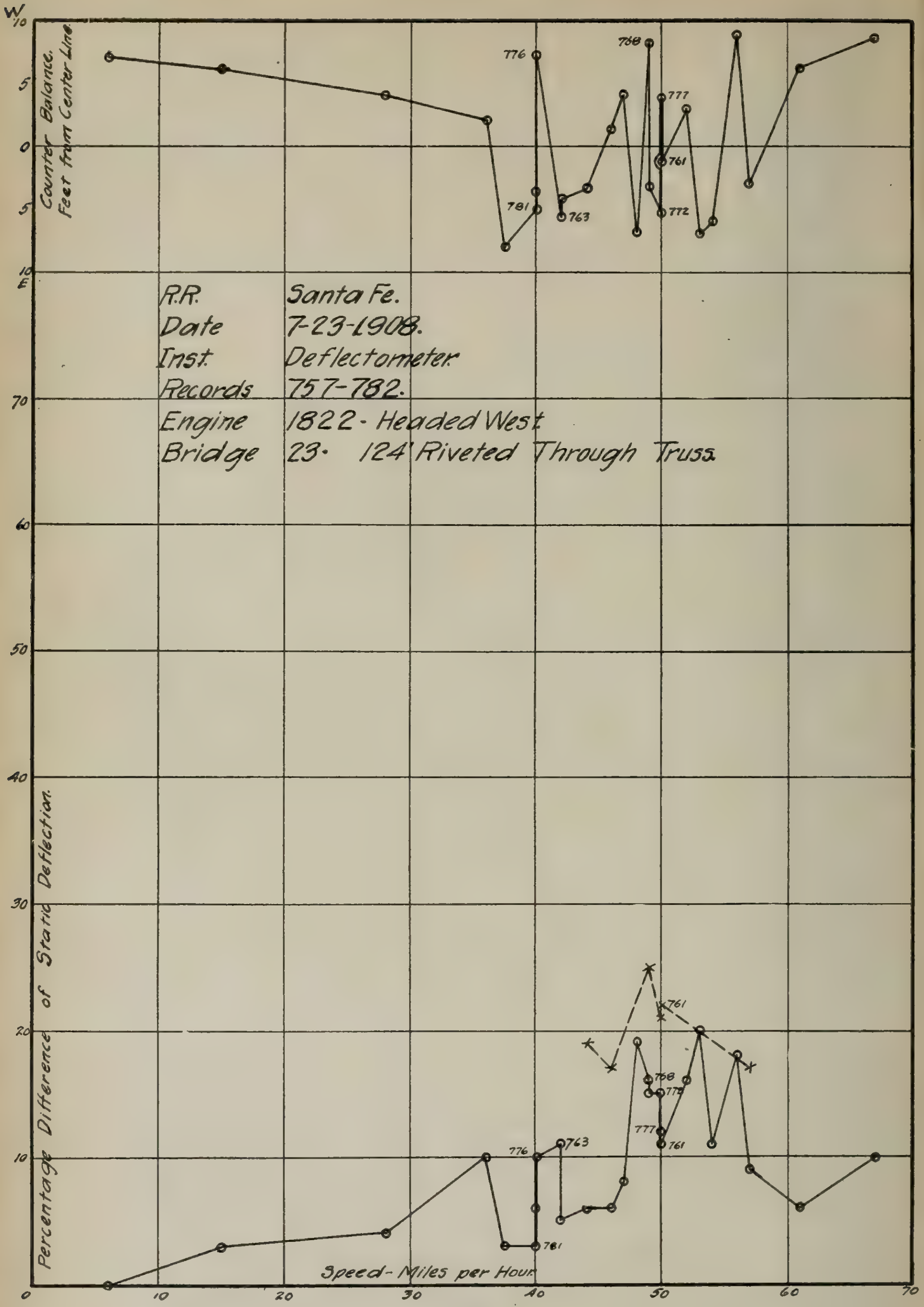

W
10
5
0
5
10
E
Counter Balance. Feet from Center Line.
776
768
777
761
772
781
763
R.R. Santa Fe.
Date 7-23-1908.
Inst. Deflectometer.
Records 757-782.
Engine 1822 - Headed West
Bridge 23 · 124' Riveted Through Truss.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
761
768
772
777
761
776
763
781
Speed - Miles per Hour.
0
10
20
30
40
50
60
70

PLATE III—ag.

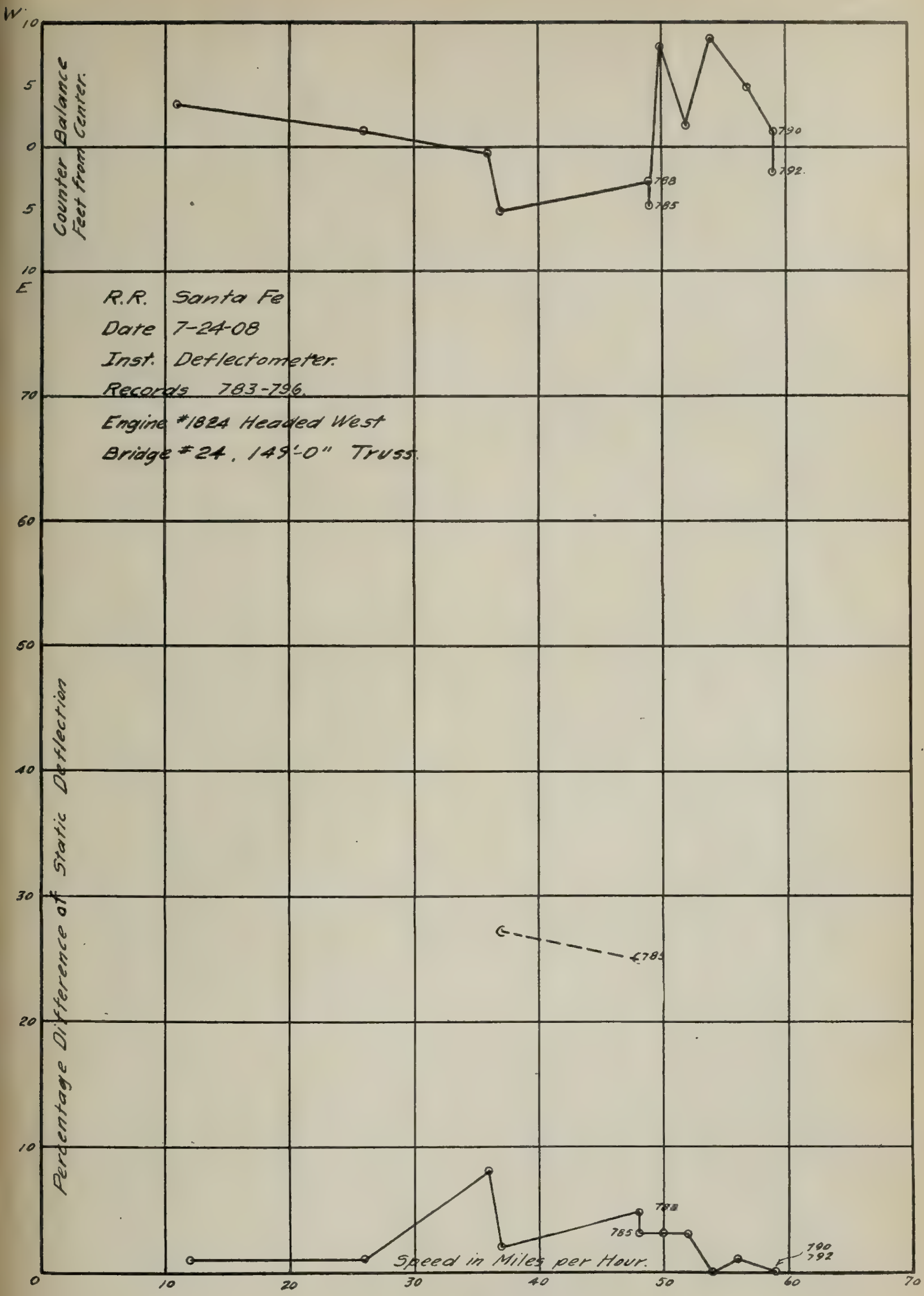
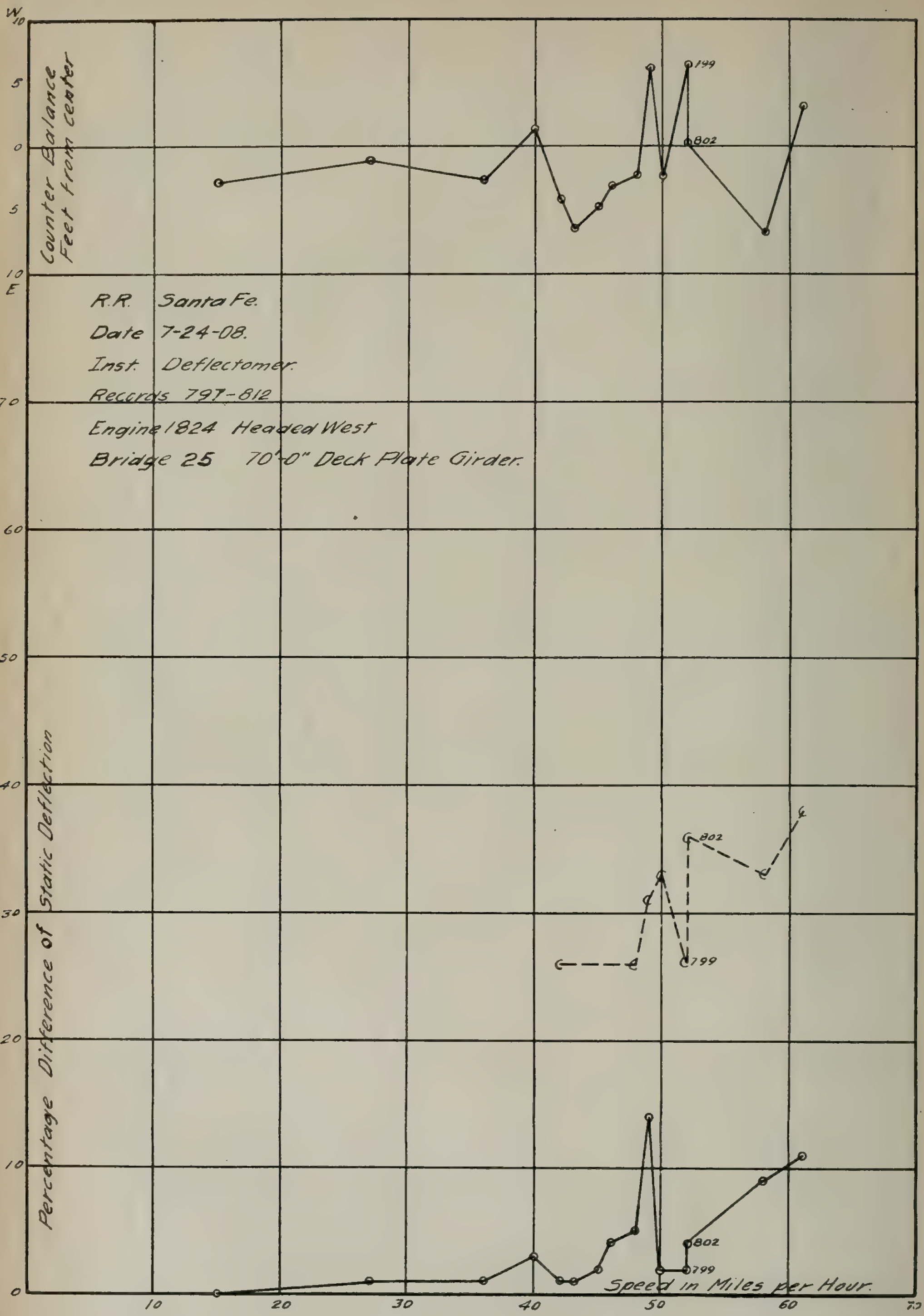

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
788
785
790
792.
R.R. Santa Fe
Date 7-24-08
Inst. Deflectometer.
Records 783-796.
Engine #1824 Headed West
Bridge #24, 149'-0" Truss.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
785
788
785
790
792
Speed in Miles per Hour.
10
20
30
40
50
60
70

PLATE III—ah.


W 10
5
0
5
10 E
Counter Balance Feet from center
R.R. Santa Fe.
Date 7-24-08.
Inst. Deflectometer.
Records 797-812
Engine 1824 Headed West
Bridge 25 70'-0" Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
799
802
Speed in Miles per Hour.
10
20
30
40
50
60
70

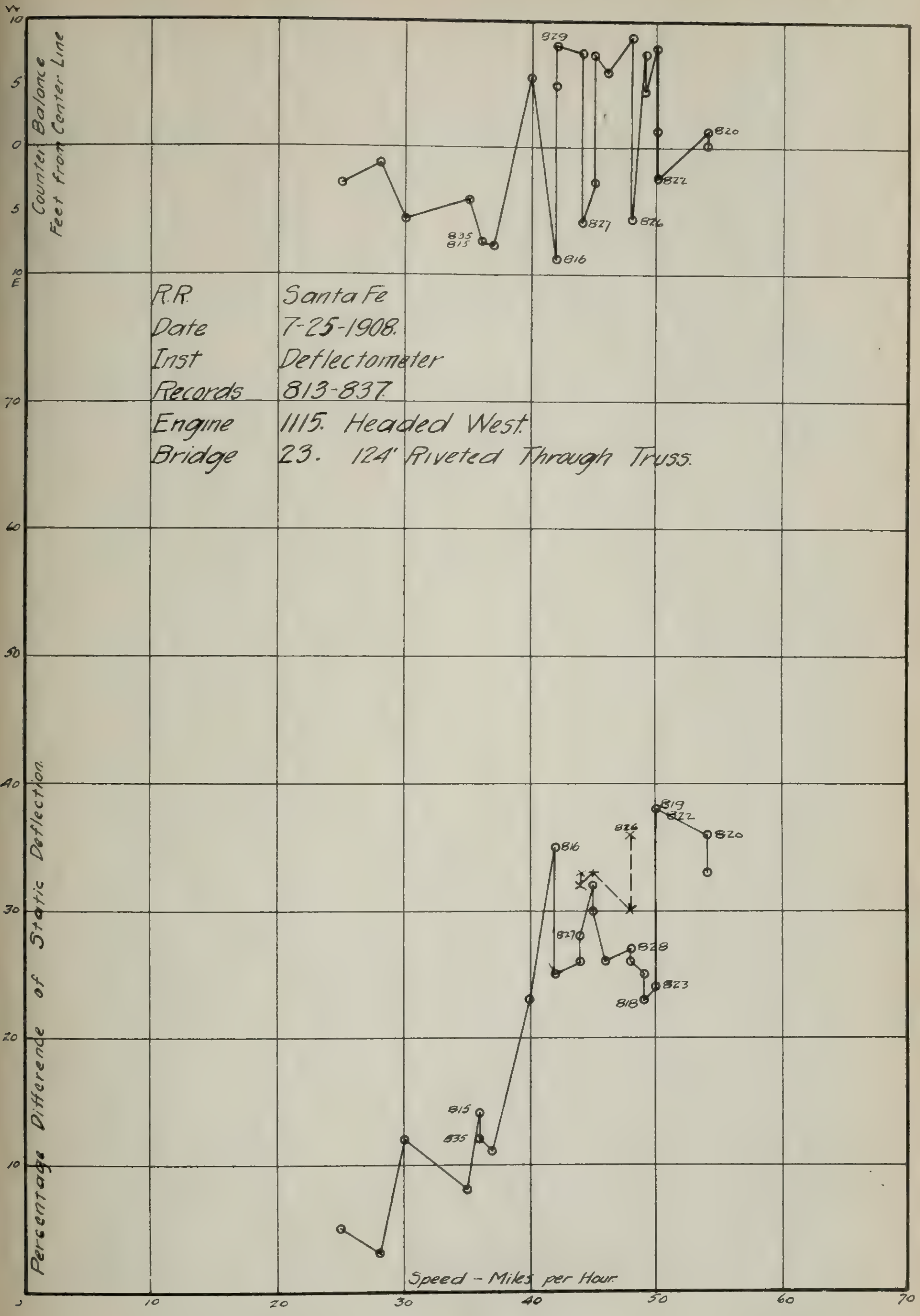
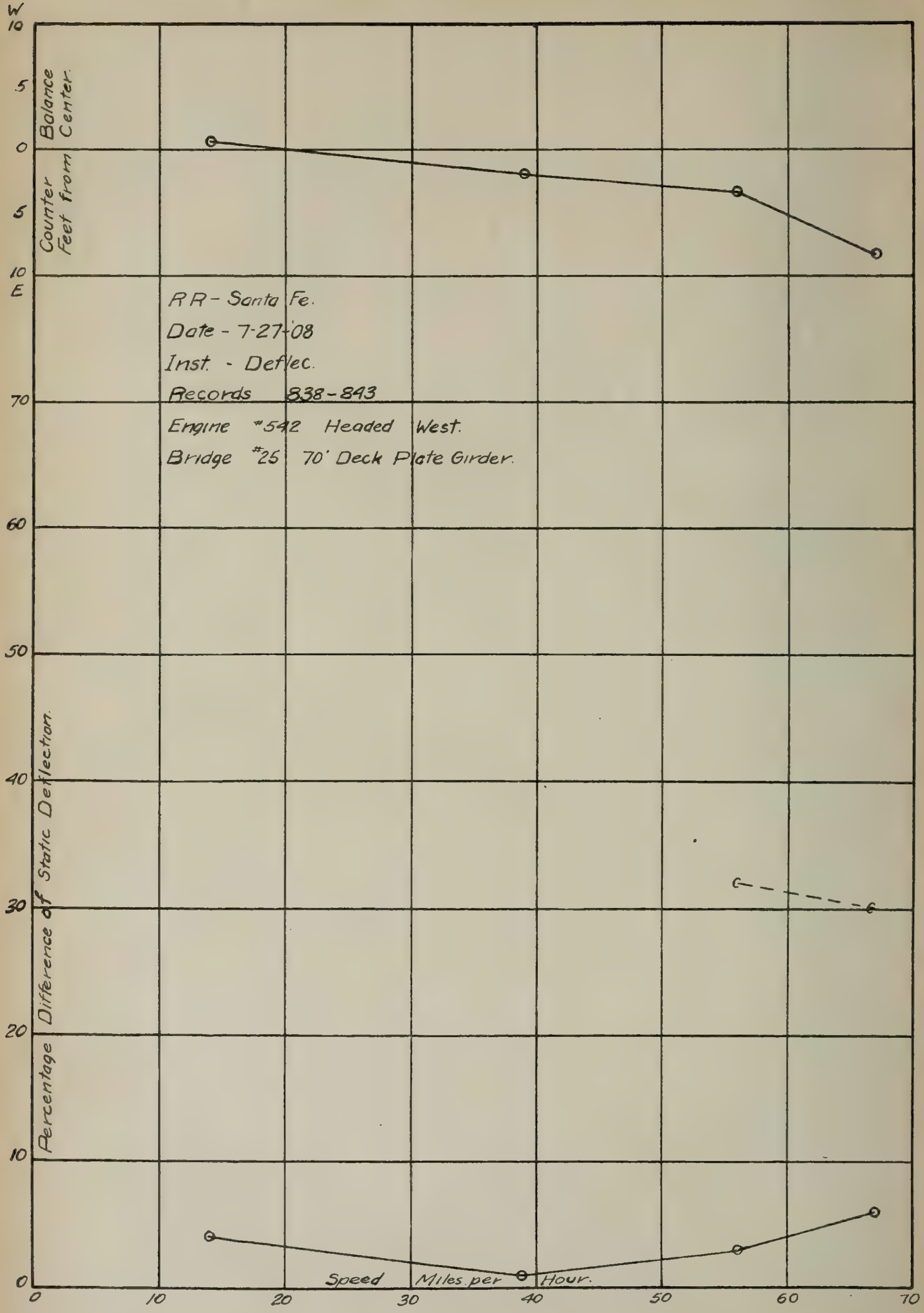
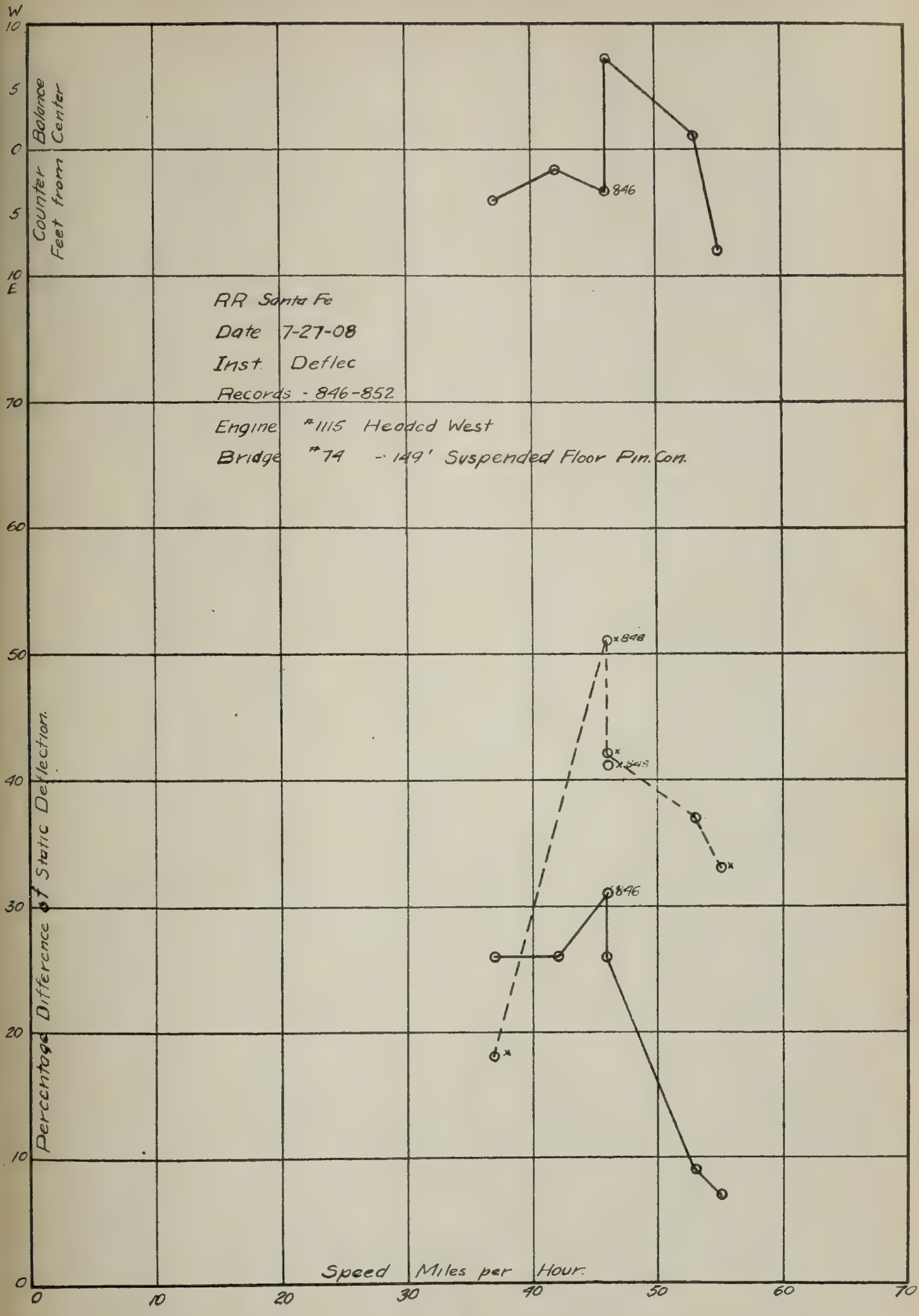

W
E
Counter Balance
Feet from Center Line
10
5
0
5
10
R.R. Santa Fe
Date 7-25-1908.
Inst Deflectometer
Records 813-837.
Engine 1115. Headed West.
Bridge 23. 124' Riveted Through Truss.
829
835
815
816
827
826
822
820
819
822
826
816
827
828
818
823
820
815
835
Percentage Difference of Static Deflection.
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
Speed – Miles per Hour.

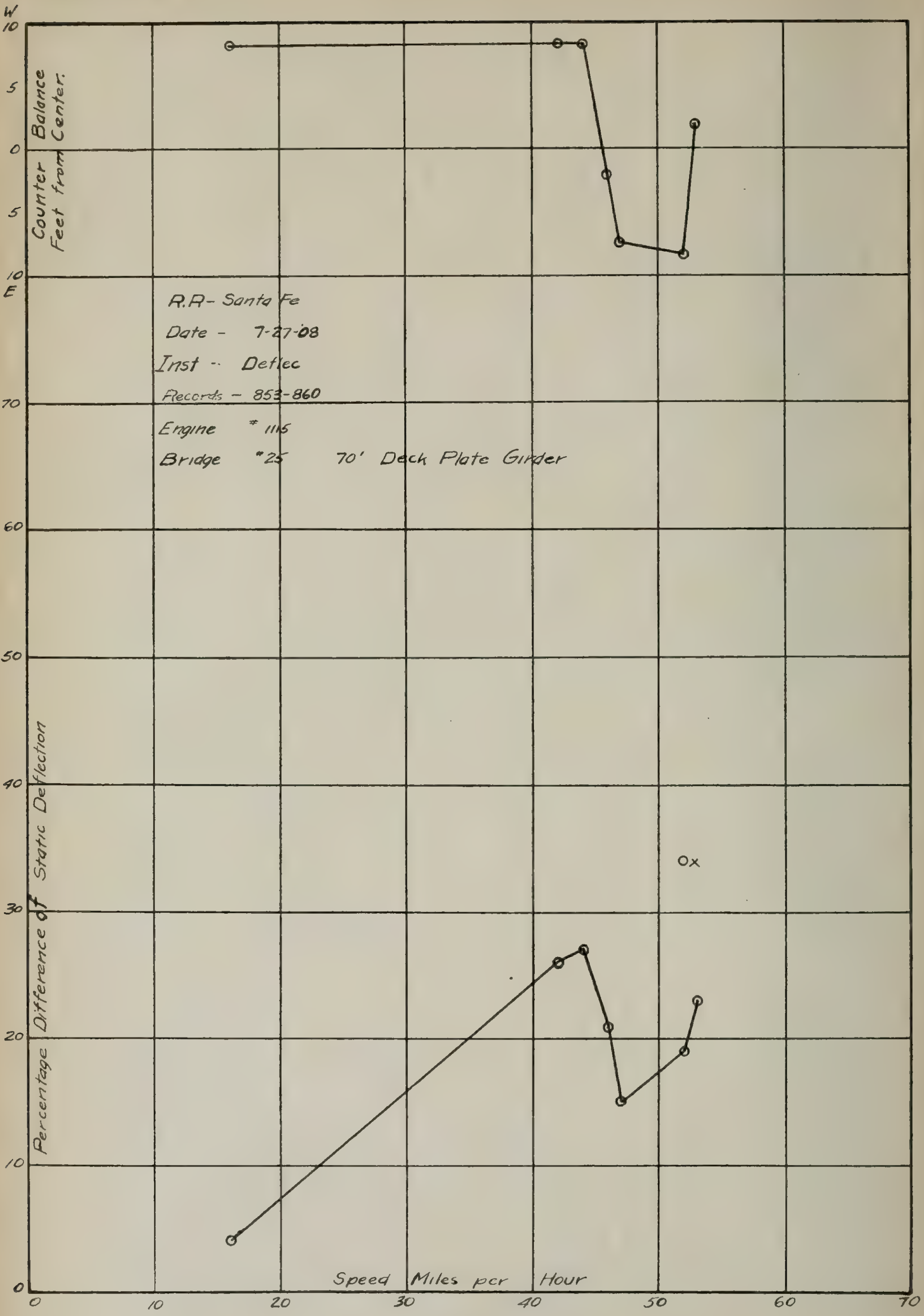
PLATE III—aj.

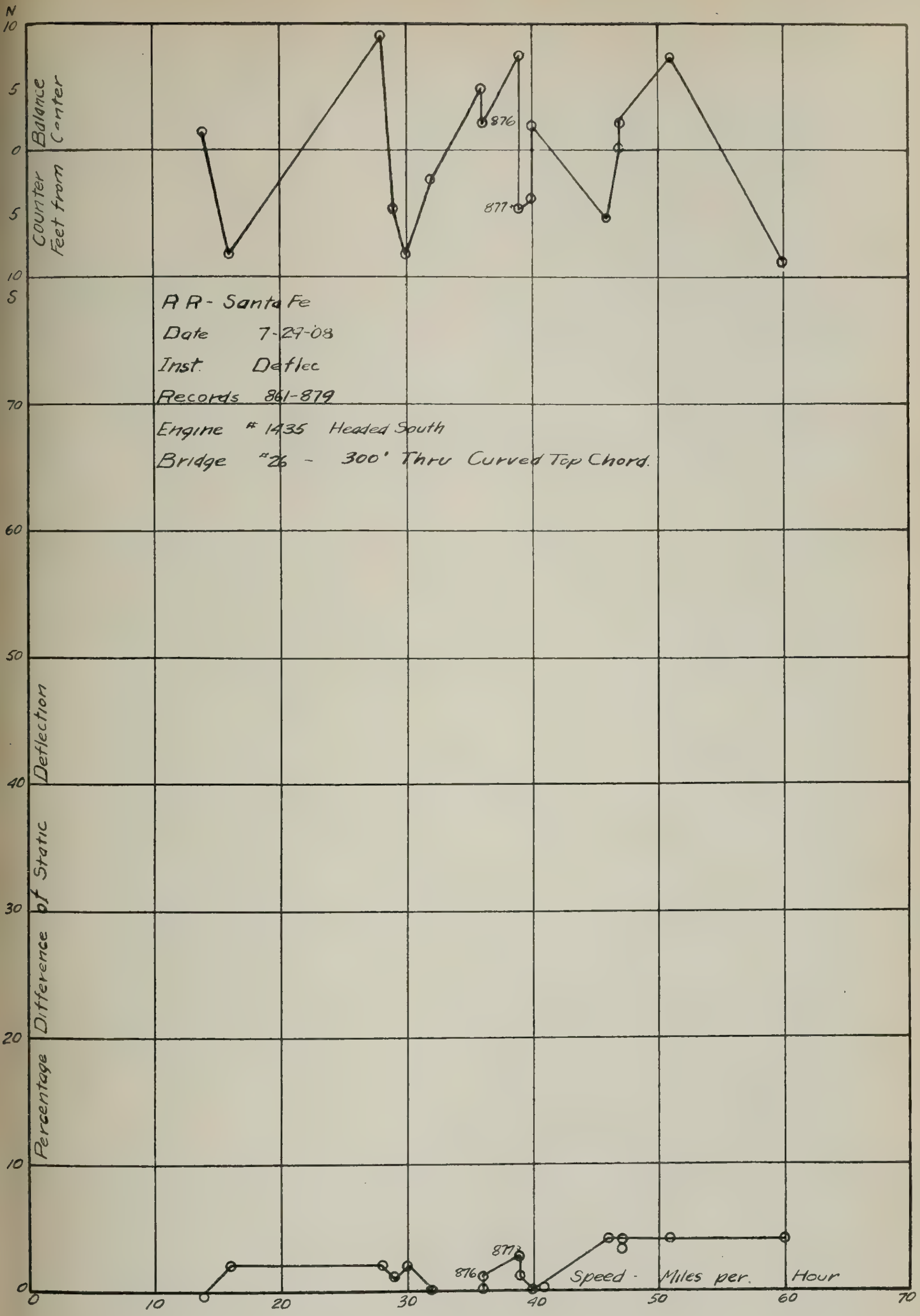

W
10
.5
0
5
10
E
Balance Center.
Counter Feet from
RR - Santa Fe.
Date - 7-27-08
Inst. - Deflec.
Records 838-843
Engine #542 Headed West.
Bridge #25 70' Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
Speed Miles per Hour.
0
10
20
30
40
50
60
70

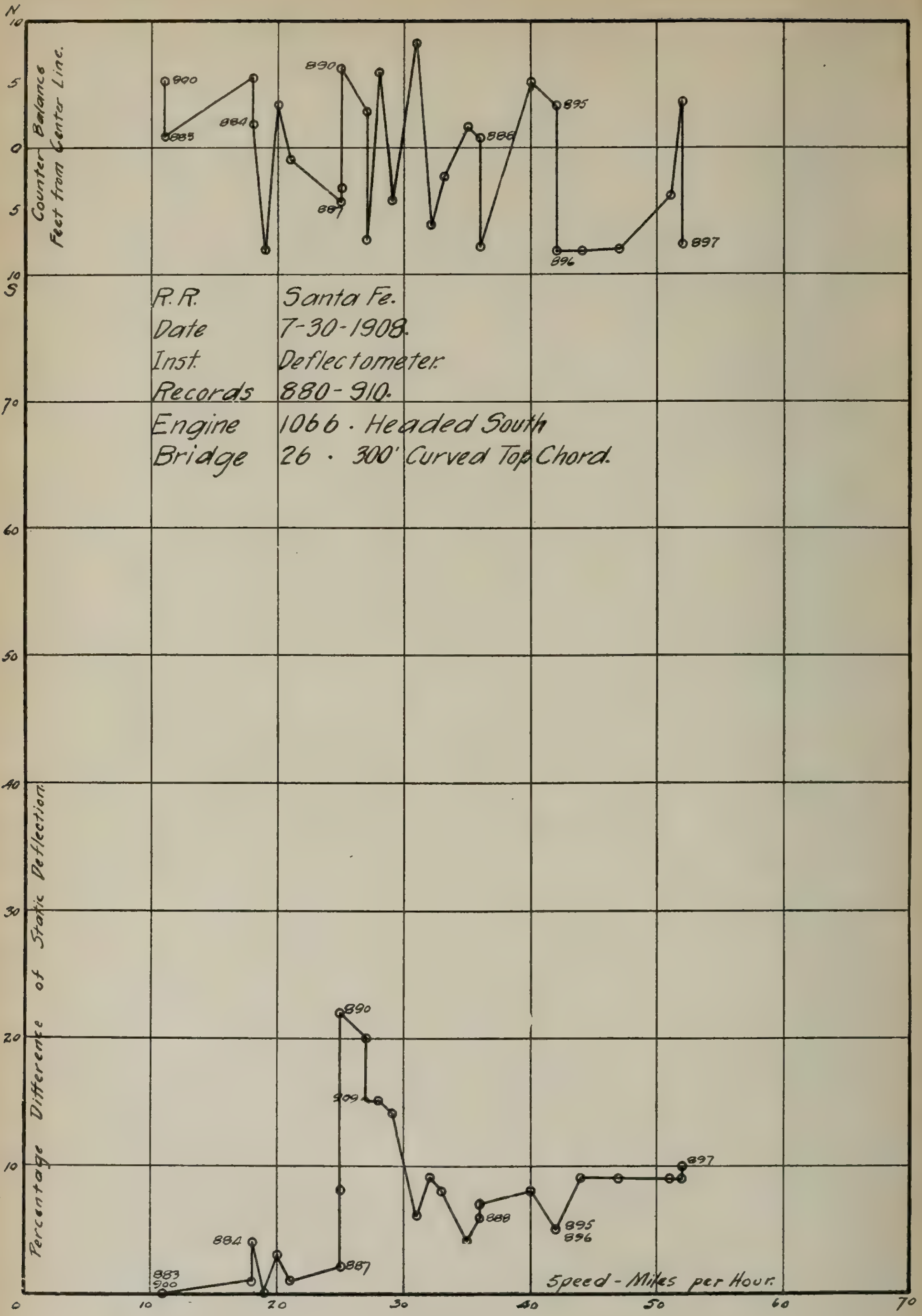


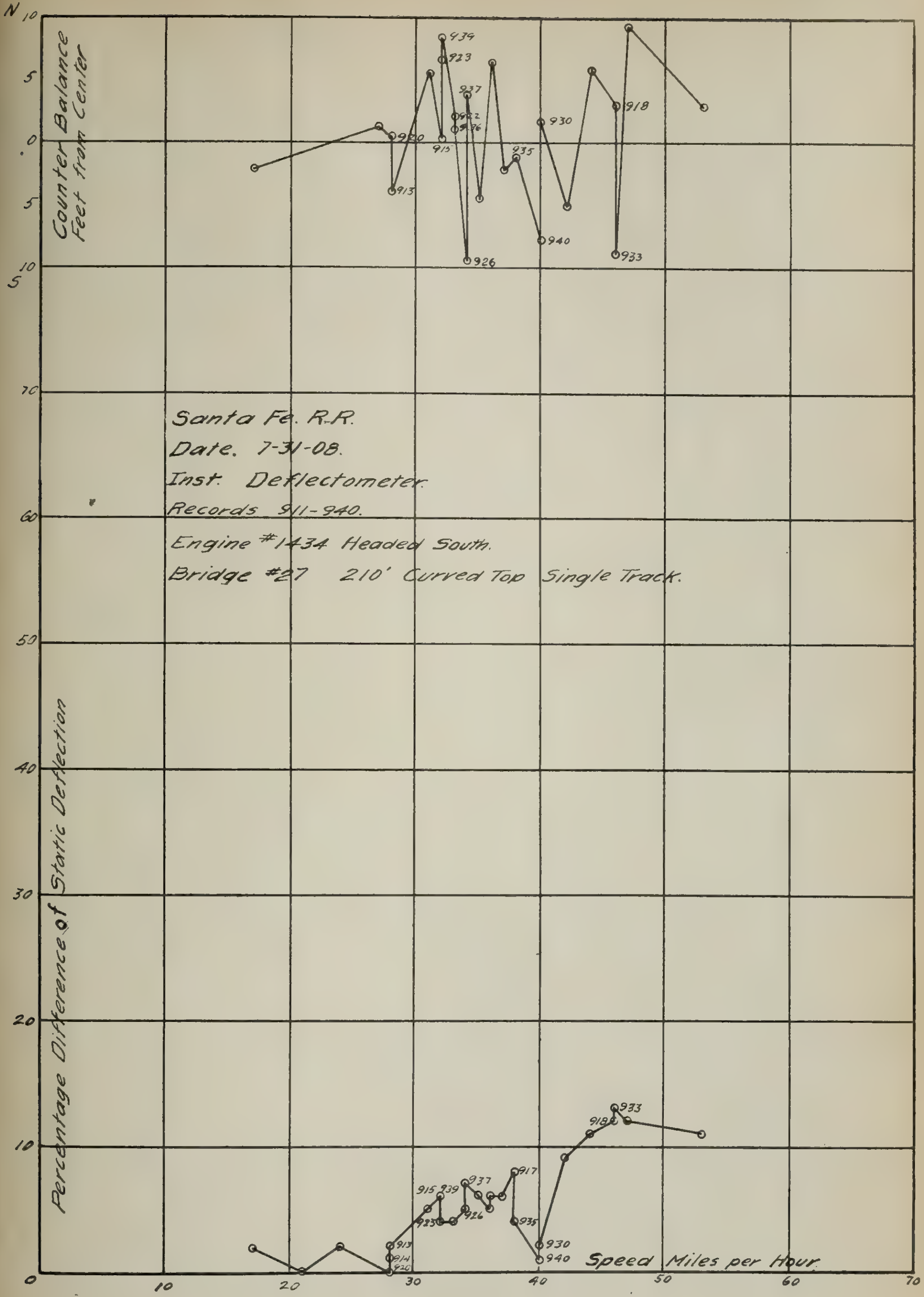
RR Santa Fe
Date 7-27-08
Inst. Deflec
Records - 846-852
Engine #1115 Headed West
Bridge #74 - 149' Suspended Floor Pin. Con.

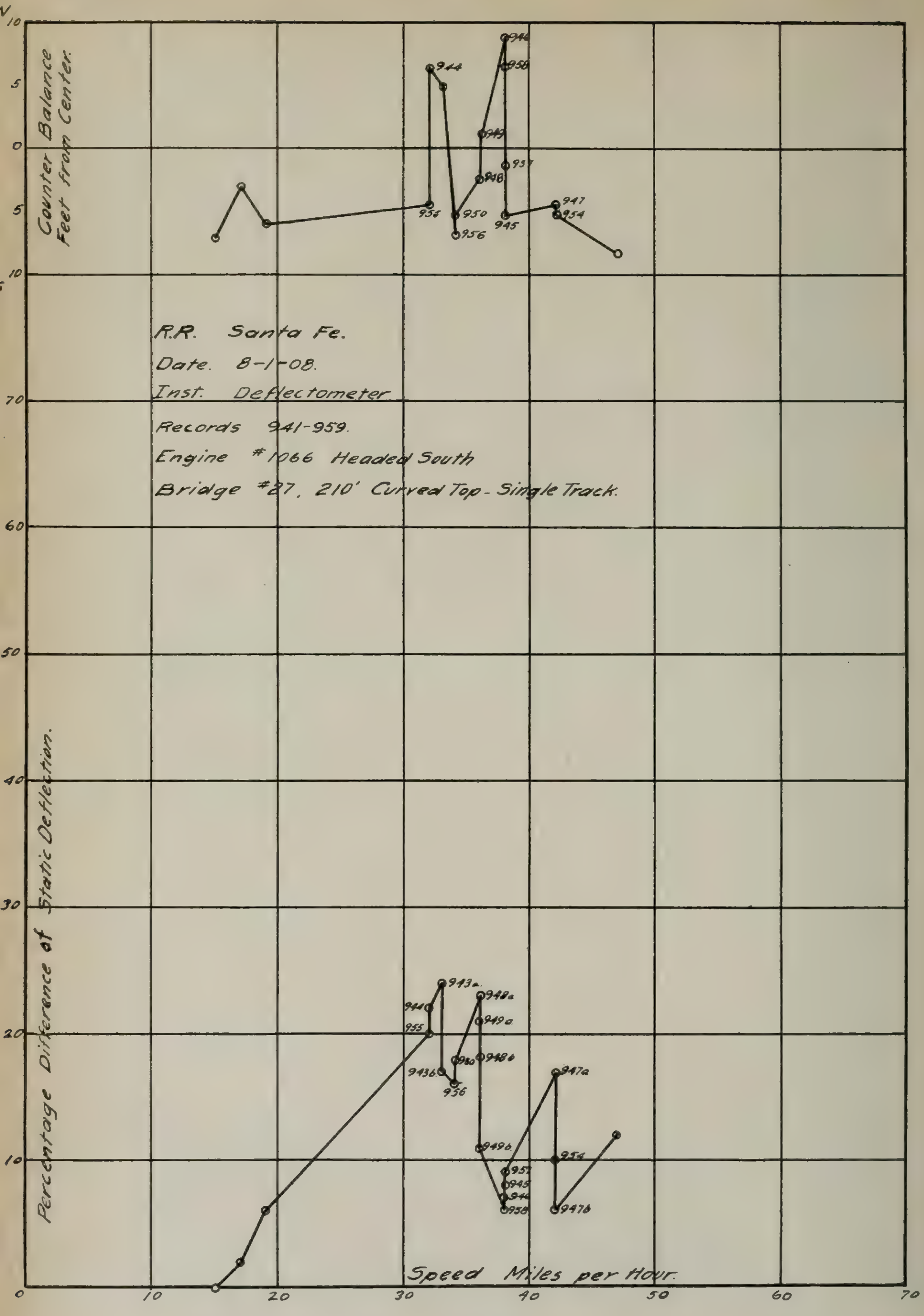
PLATE III—al.


W
10
5
0
5
10
E
Counter Balance
Feet from Center.
R.R- Santa Fe
Date - 7-27-08
Inst -- Deflec
Records - 853-860
Engine # 1115
Bridge #25 70' Deck Plate Girder
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
Ox
Speed Miles per Hour
0
10
20
30
40
50
60
70

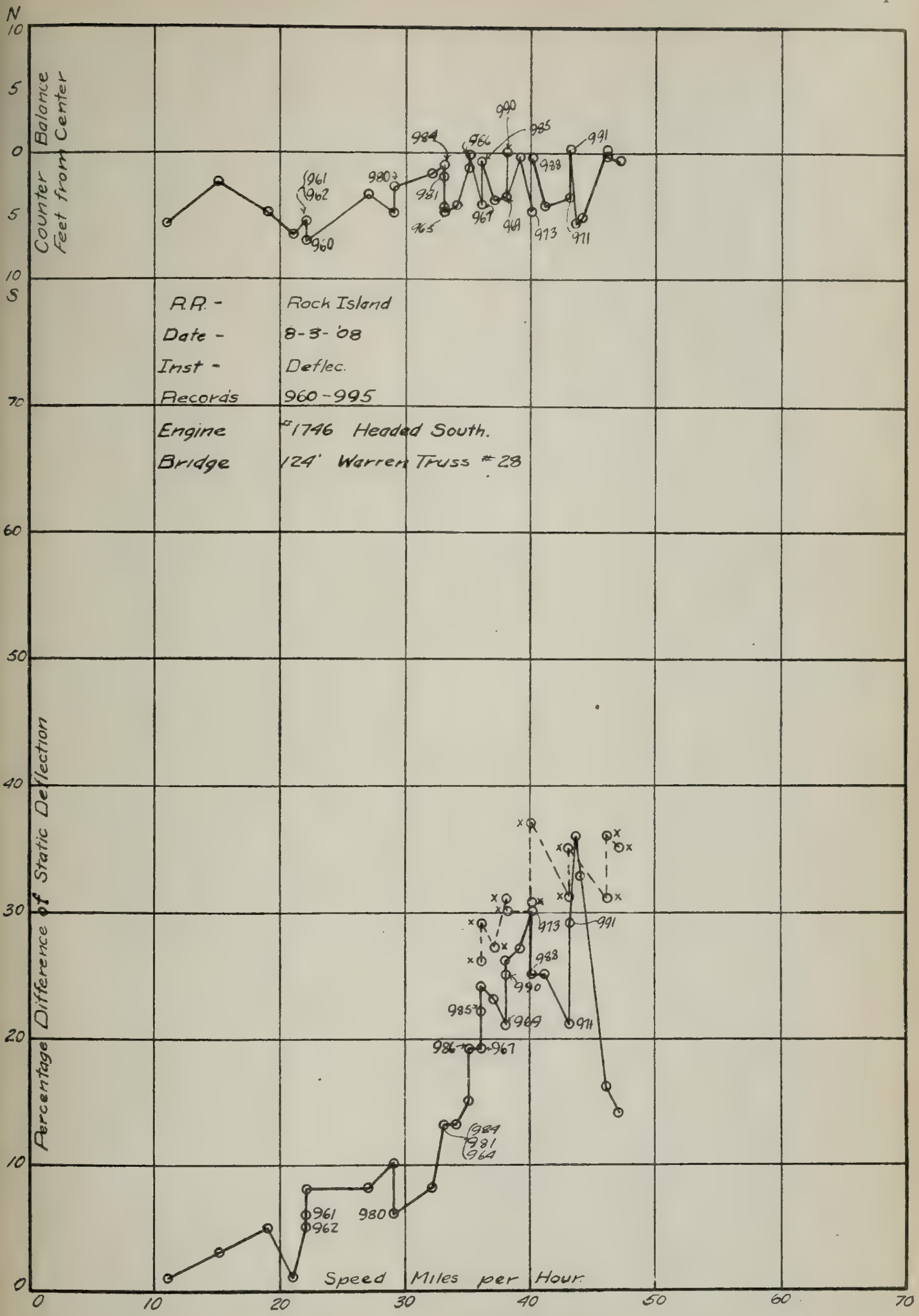

N
10
5
0
5
10
S
Balance Center
Counter Feet from
876
877
R R - Santa Fe
Date 7-29-08
Inst. Deflec
Records 861-879
Engine # 1435 Headed South
Bridge #26 - 300' Thru Curved Top Chord.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
876
877
Speed - Miles per Hour
0
10
20
30
40
50
60
70

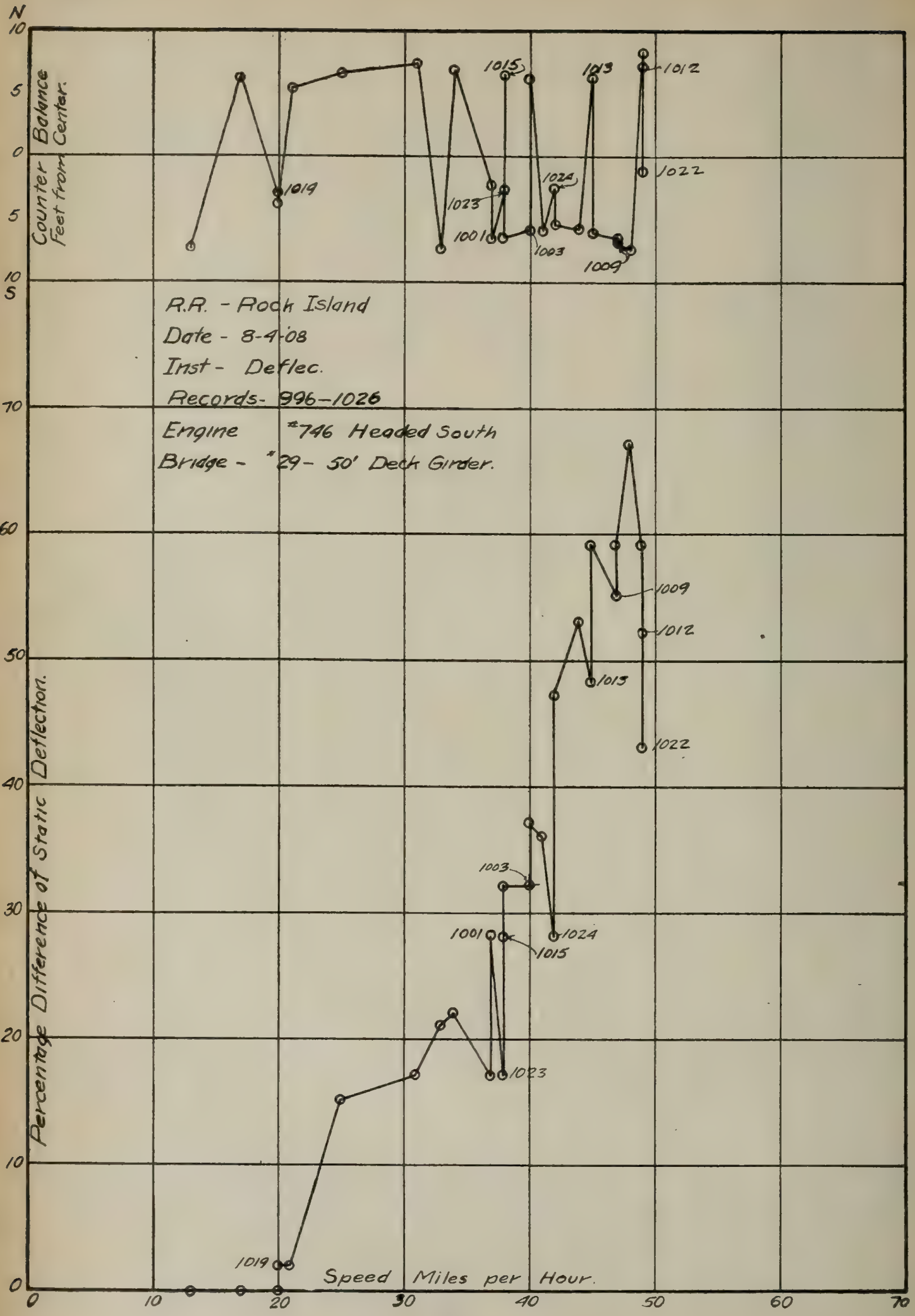

N
10
5
0
5
10
S
Counter Balance
Feet from Center Line.
880
883
884
890
887
888
895
896
897
R.R. Santa Fe.
Date 7-30-1908.
Inst. Deflectometer.
Records 880-910.
Engine 1066 · Headed South
Bridge 26 · 300' Curved Top Chord.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
890
909
884
883
900
887
888
895
896
897
Speed - Miles per Hour.
10
20
30
40
50
60
70

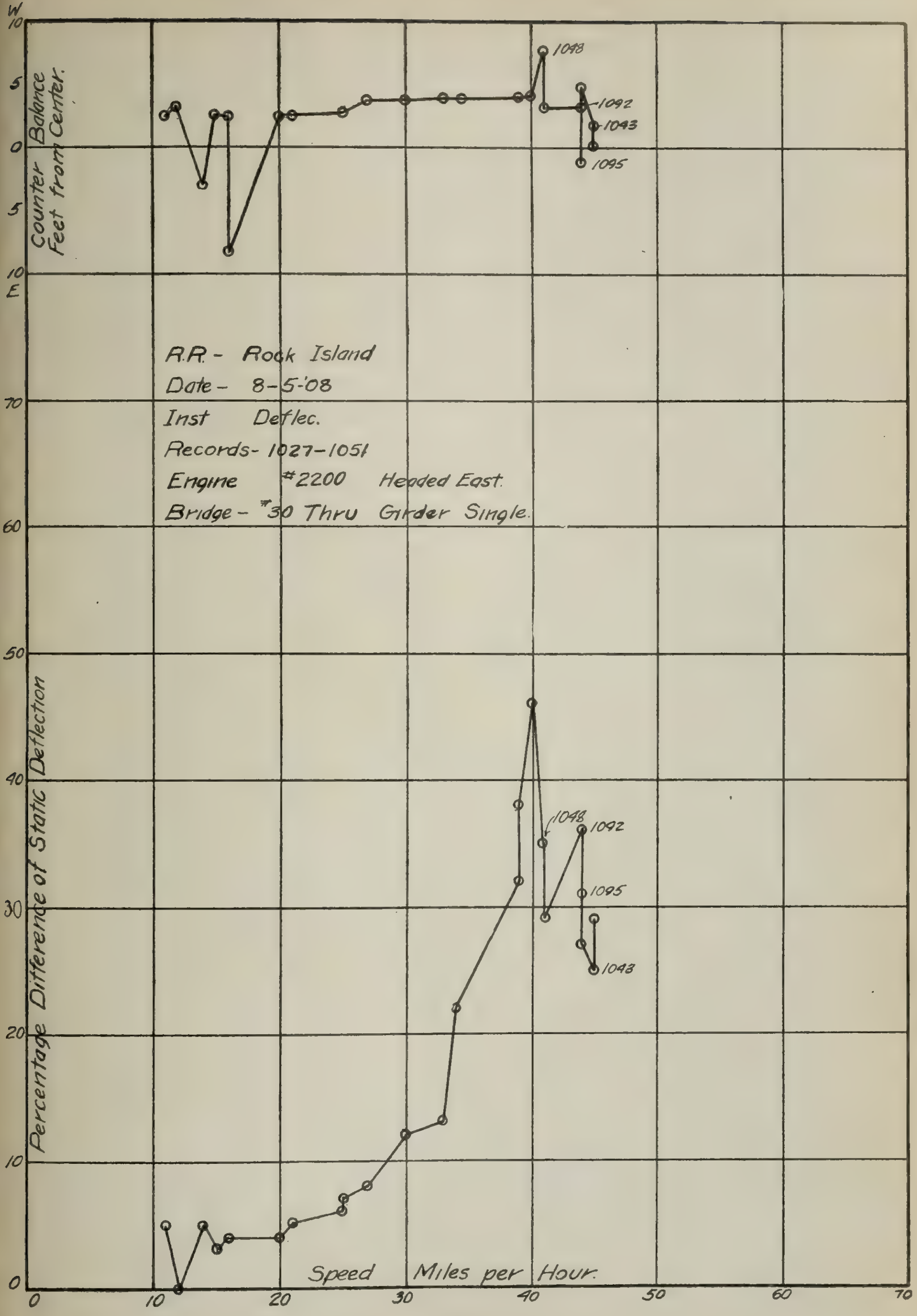

N
S
Counter Balance
Feet from Center
10
5
0
5
10
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
Santa Fe. R.R.
Date. 7-31-08.
Inst. Deflectometer.
Records 911-940.
Engine #1434 Headed South.
Bridge #27 210' Curved Top Single Track.
939
923
937
922
936
920
915
935
913
930
918
940
926
933
917
914
939
937
915
926
930
940
Speed Miles per Hour.
10
20
30
40
50
60
70

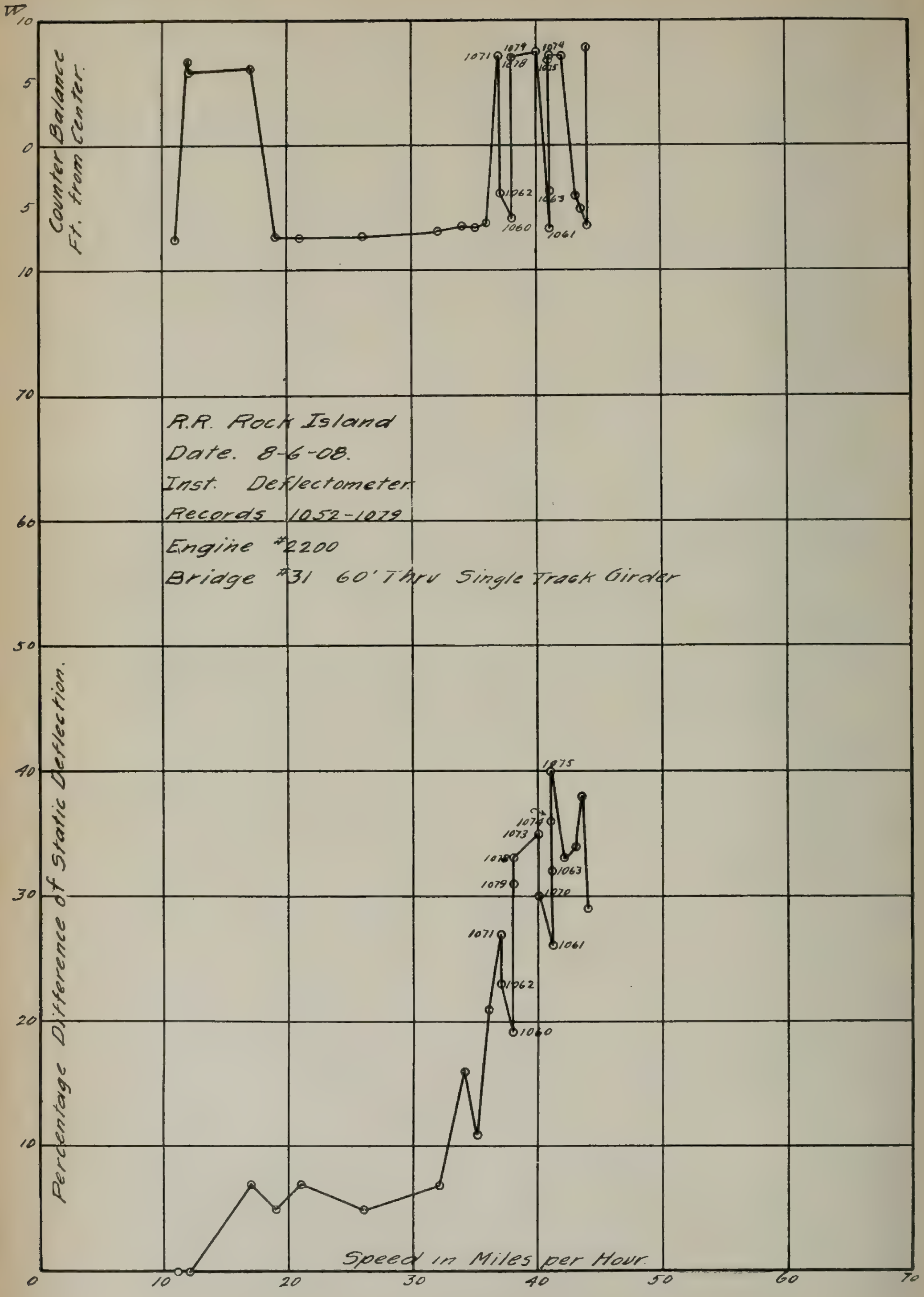


R.R. Santa Fe.
Date. 8-1-08.
Inst. Deflectometer
Records 941-959.
Engine #1066 Headed South
Bridge #27, 210' Curved Top - Single Track.


N
10
5
0
5
10
S
Counter Balance
Feet from Center
961
962
960
980
981
965
984
966
990
985
967
969
988
973
971
991
R.R. - Rock Island
Date - 8-3-'08
Inst - Deflec.
Records 960-995
Engine #1746 Headed South.
Bridge 124' Warren Truss #28
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
973
991
988
990
985
969
971
986
967
984
981
964
961
962
980
Speed Miles per Hour
0
10
20
30
40
50
60
70

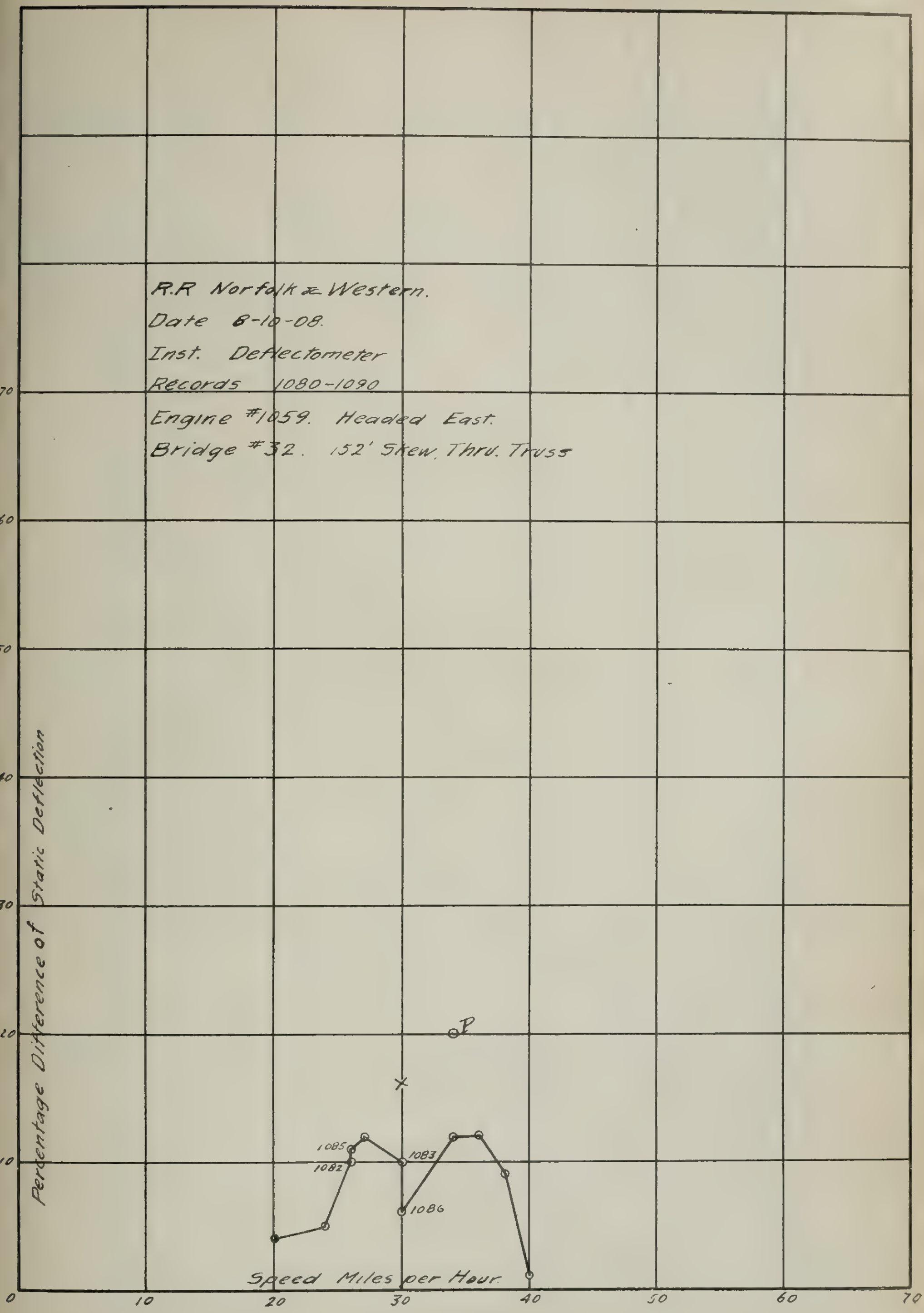

N
10
5
0
5
10
S
Counter Balance
Feet from Center.
1015
1013
1012
1019
1024
1022
1023
1001
1003
1009
R.R. - Rock Island
Date - 8-4-08
Inst - Deflec.
Records - 996–1026
Engine #746 Headed South
Bridge - #29 - 50' Deck Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1009
1012
1013
1022
1003
1001
1024
1015
1023
1019
Speed Miles per Hour.
0
10
20
30
40
50
60
70

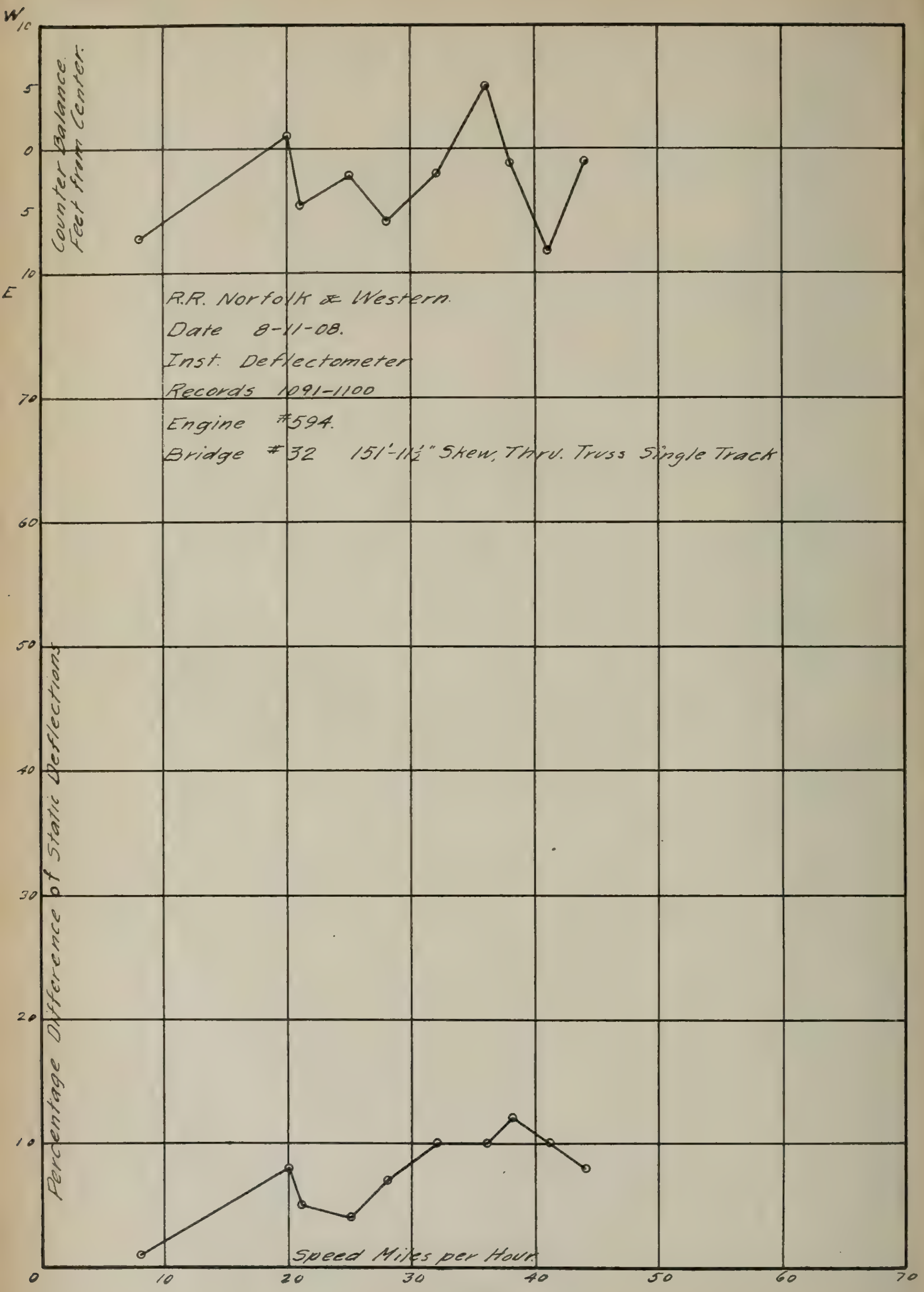

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
1048
1092
1043
1095
R.R.- Rock Island
Date- 8-5-'08
Inst Deflec.
Records- 1027-1051
Engine #2200 Headed East.
Bridge- #30 Thru Girder Single.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
1048
1092
1095
1043
Speed Miles per Hour.
0
10
20
30
40
50
60
70



R.R. Rock Island
Date. 8-6-08.
Inst. Deflectometer
Records 1052-1079
Engine #2200
Bridge #31 60' Thru Single Track Girder

PLATE III—an.


R.R Norfolk & Western.
Date 8-10-08.
Inst. Deflectometer
Records 1080-1090
Engine #1059. Headed East.
Bridge #32. 152' Skew, Thru. Truss
Percentage Difference of Static Deflection
Speed Miles per Hour.
0
10
20
30
40
50
60
70
1085
1082
1083
1086
P
×


W
10
5
0
5
10
E
Counter Balance Feet from Center.
R.R. Norfolk & Western.
Date 8-11-08.
Inst. Deflectometer
Records 1091-1100
Engine #594.
Bridge #32 151'-11½" Skew, Thru. Truss Single Track
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflections
Speed Miles per Hour
10
20
30
40
50
60
70

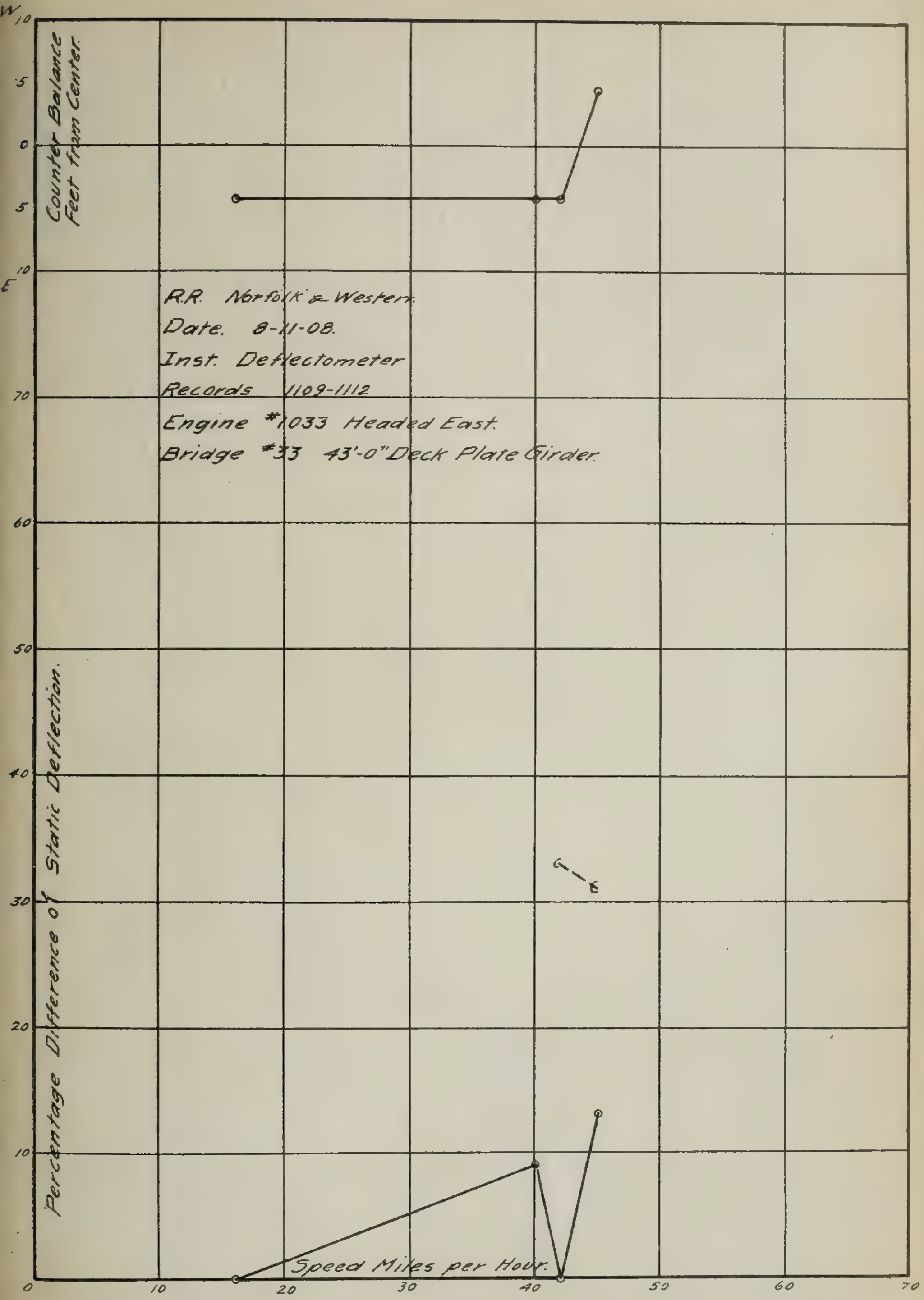
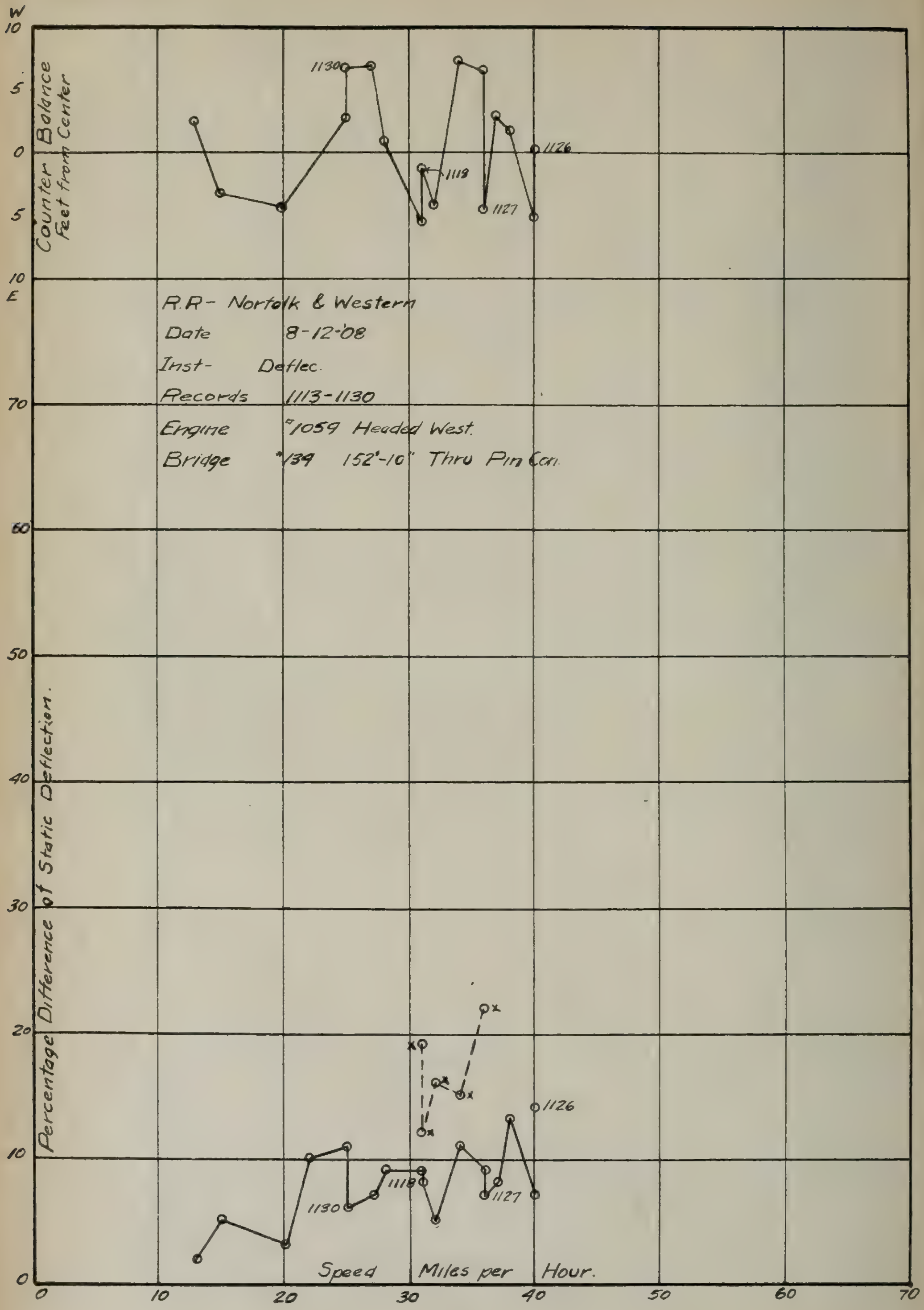

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
R.R. Norfolk & Western.
Date. 8-11-08.
Inst. Deflectometer
Records 1109-1112
Engine #1033 Headed East.
Bridge #33 43'-0" Deck Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
Speed Miles per Hour.
10
20
30
40
50
60
70

PLATE III—ax.



W
10
5
0
5
10
E
Counter Balance Feet from Center
1130
1118
1127
1126
R.R- Norfolk & Western
Date 8-12-08
Inst- Deflec.
Records 1113-1130
Engine #1059 Headed West.
Bridge #139 152'-10" Thru Pin Con.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1126
1118
1130
1127
Speed Miles per Hour.
0
10
20
30
40
50
60
70

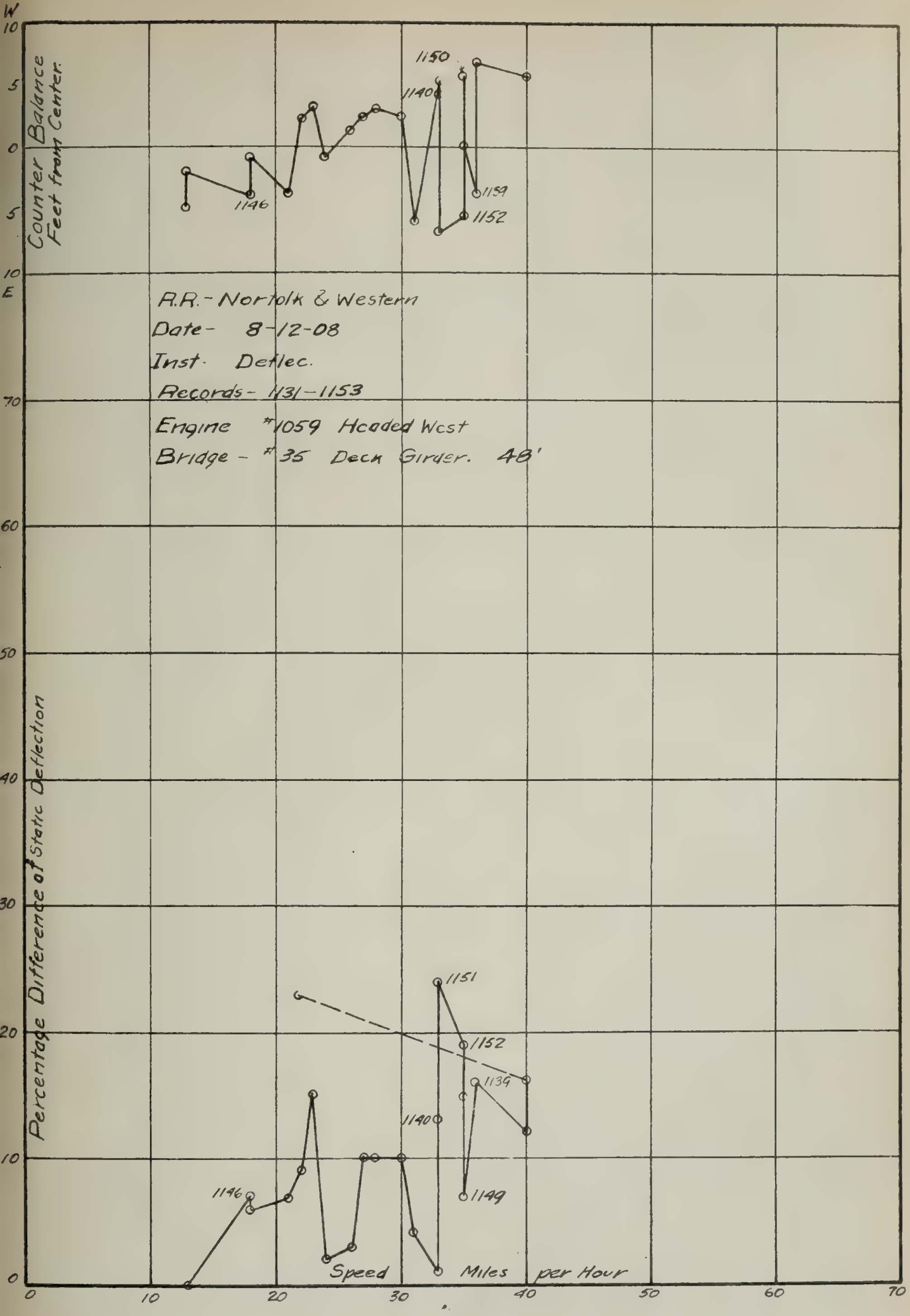
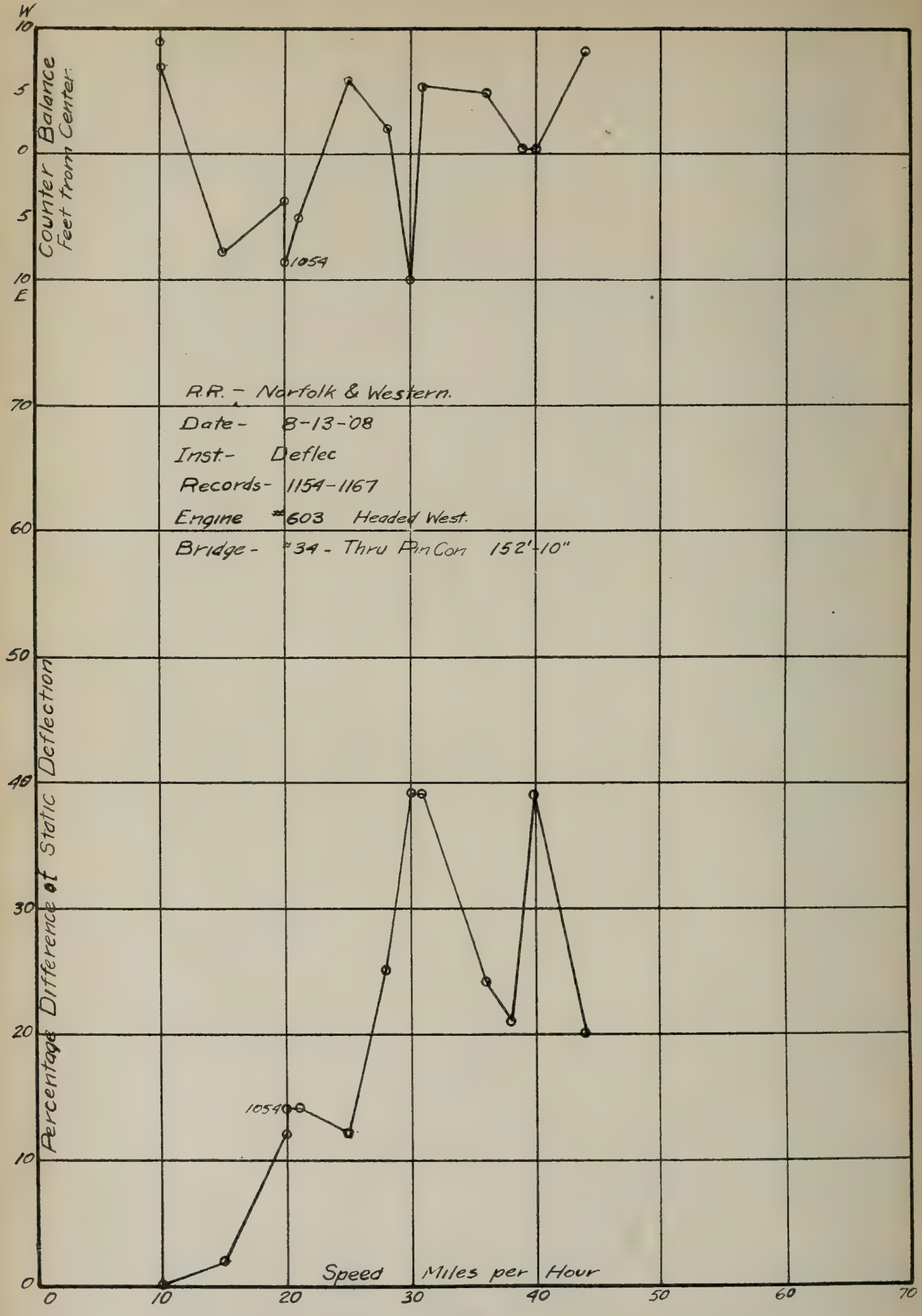
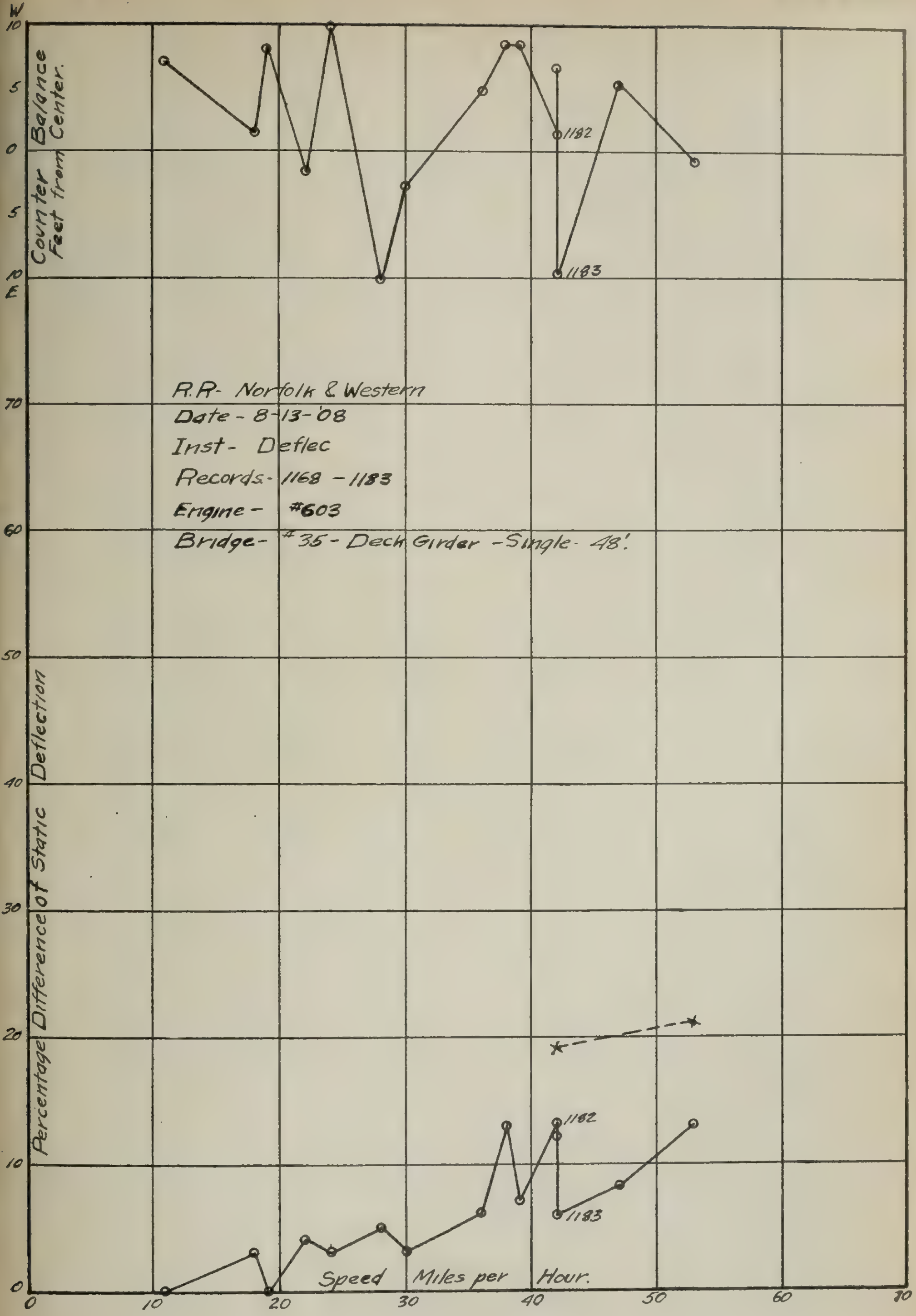
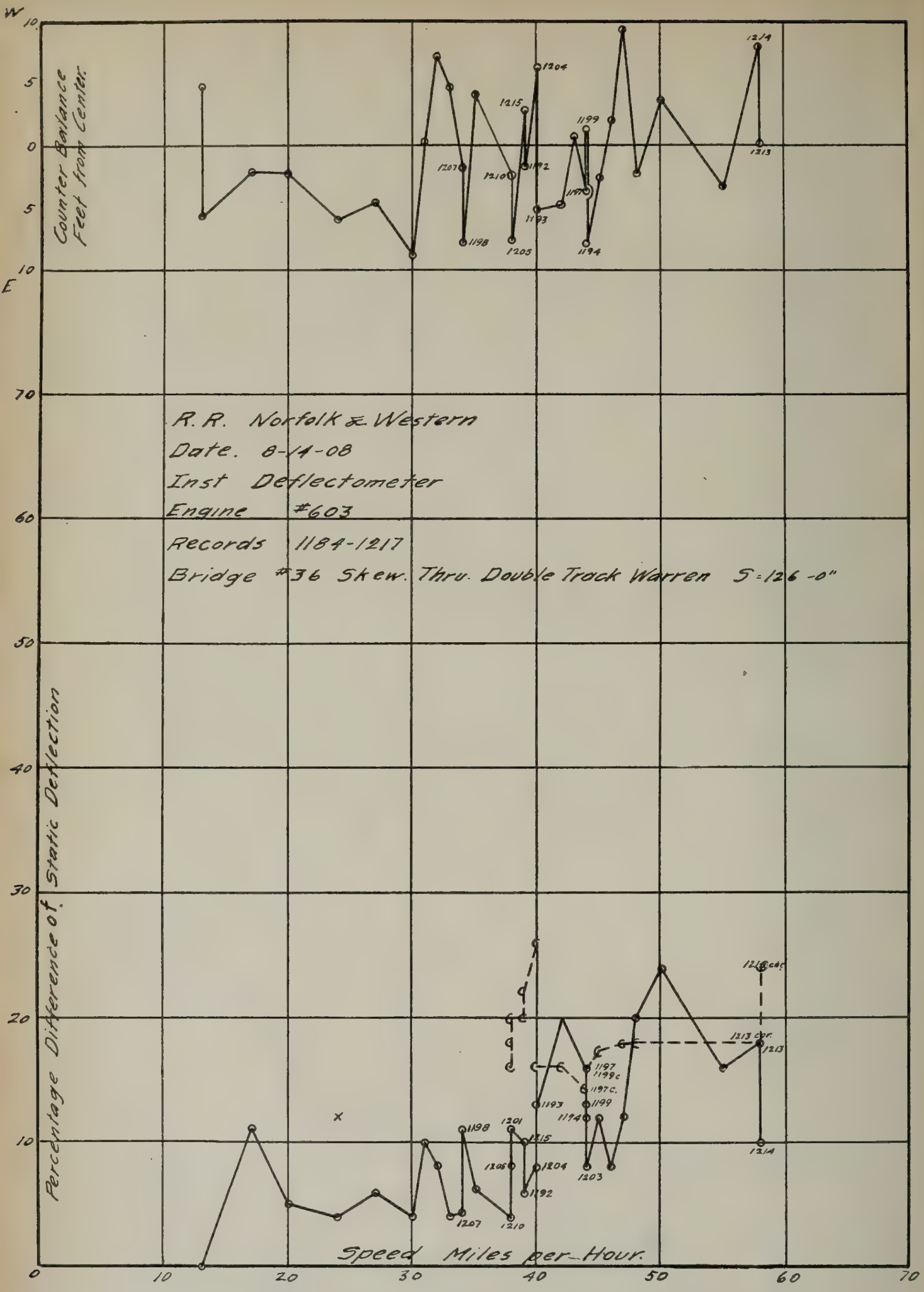

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
1150
1140
1146
1159
1152
R.R. - Norfolk & Western
Date - 8-12-08
Inst. Deflec.
Records - 1131-1153
Engine #1059 Headed West
Bridge - #35 Deck Girder. 48'
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
1151
1152
1139
1140
1146
1149
Speed Miles per Hour
0
10
20
30
40
50
60
70

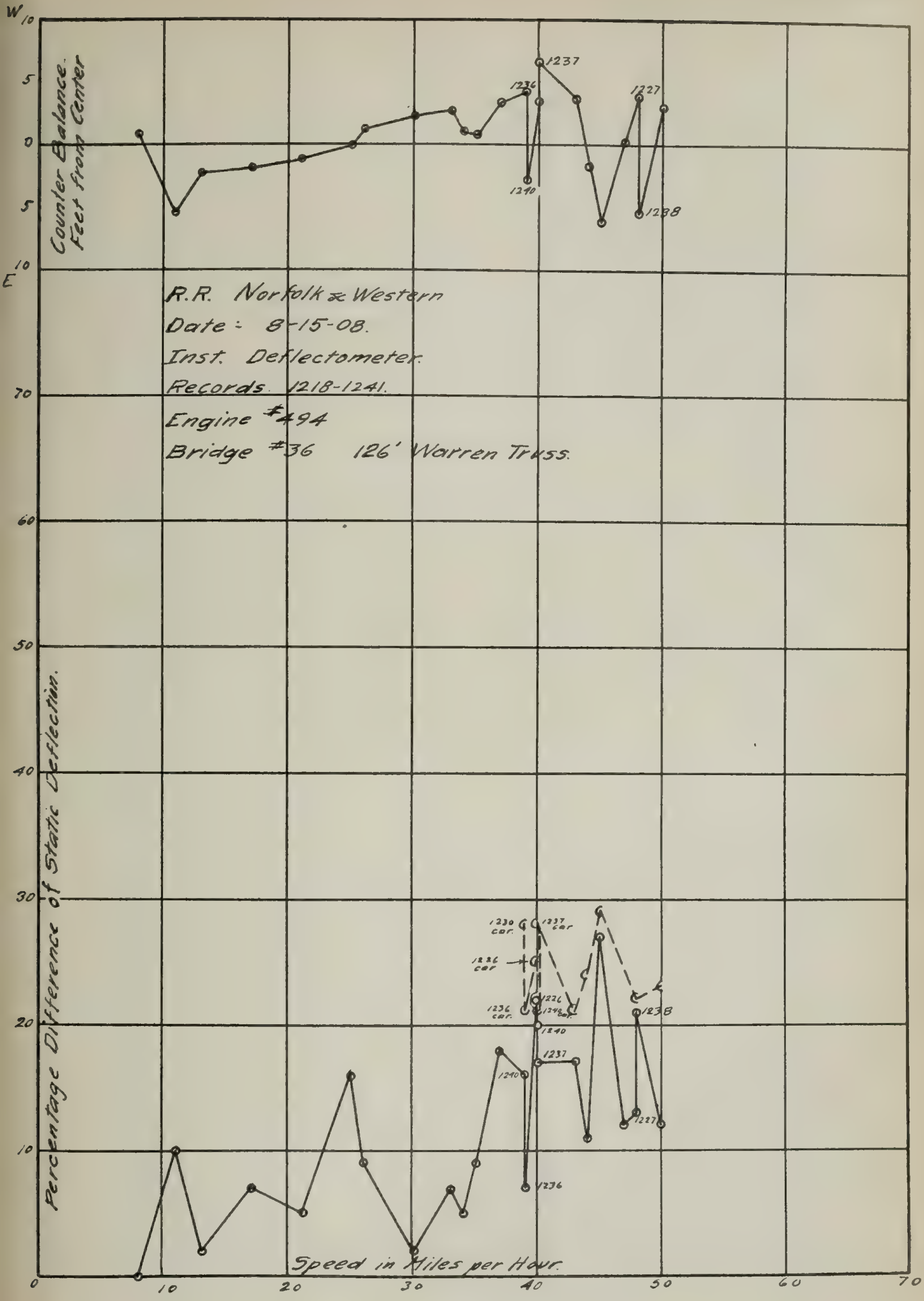
PLATE III—az.

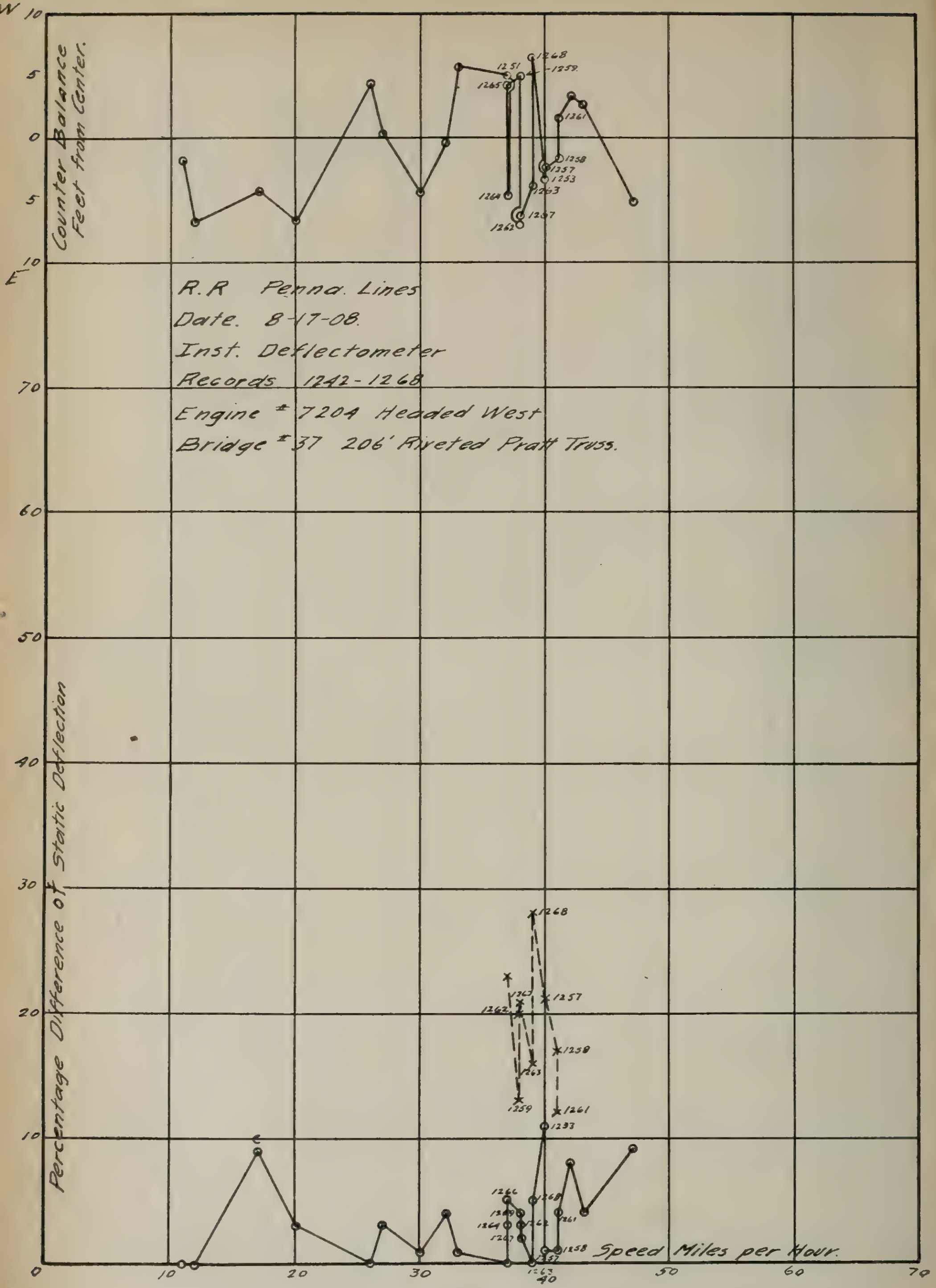

W
10
5
0
5
10
E
Counter Balance
Feet from Center
1054
R.R. - Norfolk & Western.
Date - 8-13-'08
Inst.- Deflec
Records- 1154-1167
Engine #603 Headed West.
Bridge- #34 - Thru Pin Con 152'-10"
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
1054
Speed Miles per Hour
0
10
20
30
40
50
60
70

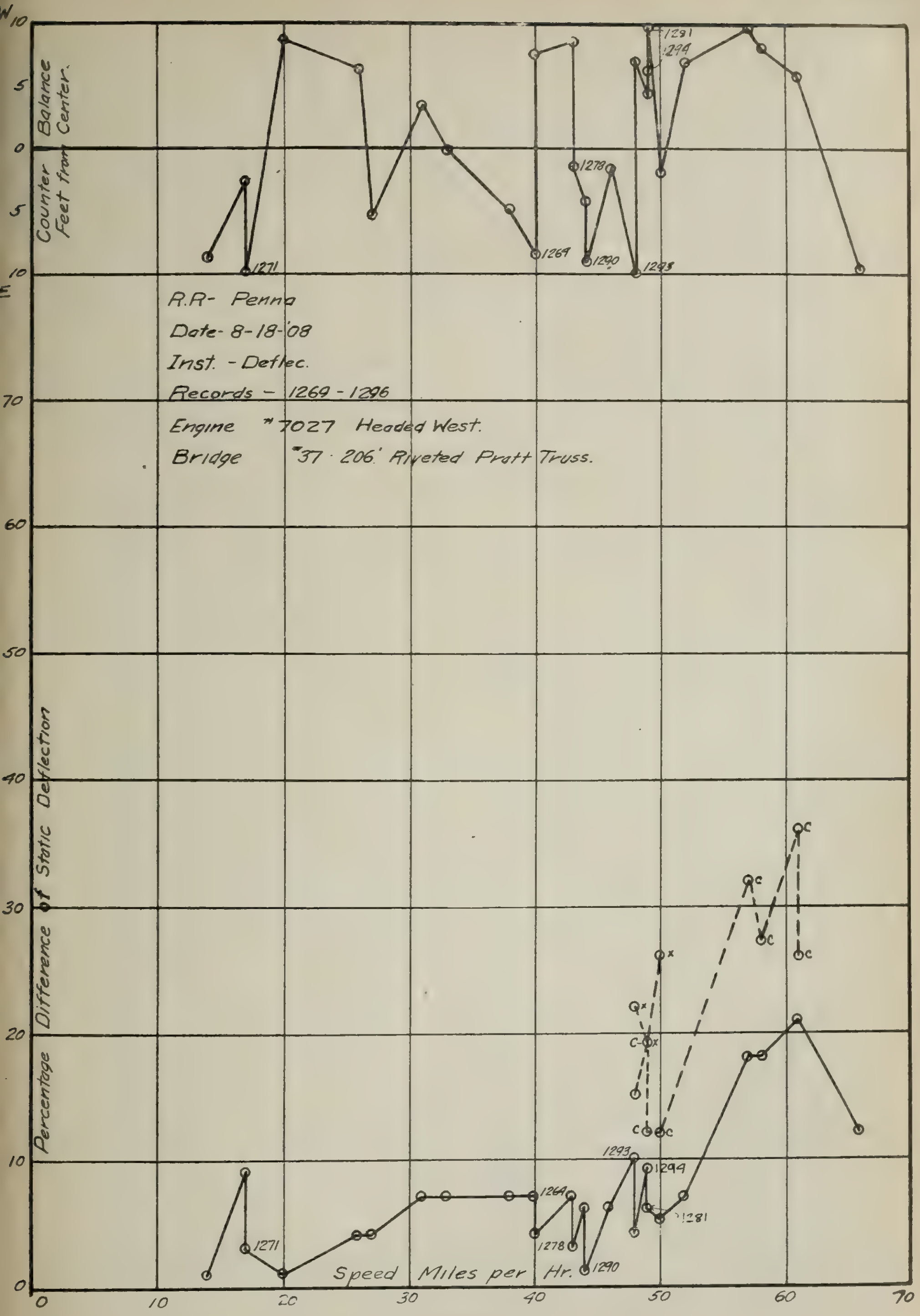

W
10
5
0
5
10
E
Counter Balance
Feet from Center.
1182
1183
R.R- Norfolk & Western
Date - 8-13-'08
Inst- Deflec
Records- 1168 - 1183
Engine - #603
Bridge- #35 - Deck Girder - Single- 48'.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
1182
1183
Speed Miles per Hour.
0
10
20
30
40
50
60
70

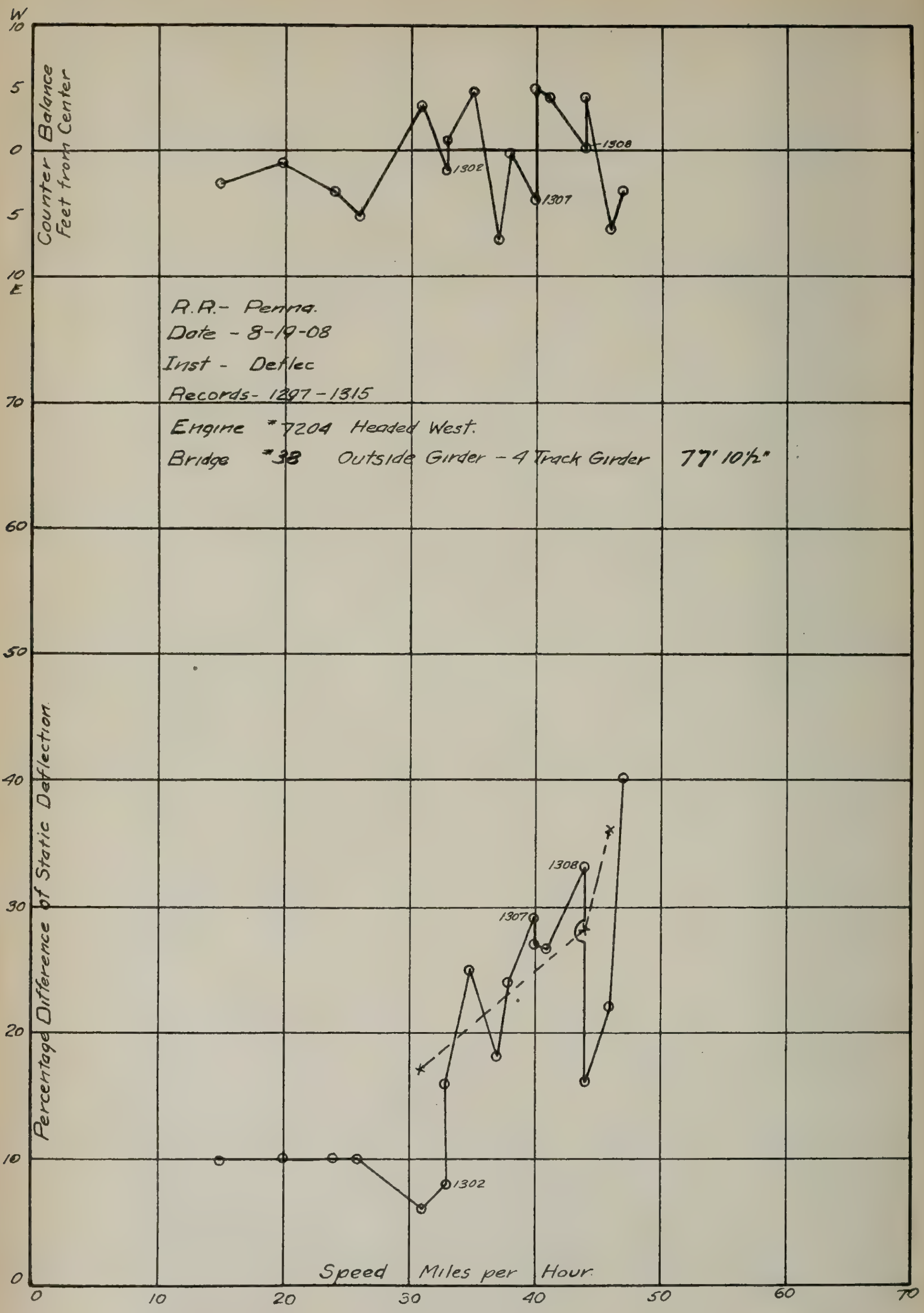


R.R. Norfolk & Western
Date. 8-14-08
Inst Deflectometer
Engine #603
Records 1184-1217
Bridge #36 Skew. Thru. Double Track Warren S=126-0"


W 10
5
0
5
10 E
Counter Balance.
Feet from Center
1236
1237
1227
1240
1238
R.R. Norfolk & Western
Date: 8-15-08.
Inst. Deflectometer.
Records. 1218-1241.
Engine #494
Bridge #36 126' Warren Truss.
70
60
50
40
30
20
10
Percentage Difference of Static Deflection.
1230 cor.
1237 cor
1226 cor
1226
1236 cor.
1240 cor.
1238
1240
1237
1240
1227
1236
Speed in Miles per Hour.
0
10
20
30
40
50
60
70


W
E
Counter Balance Feet from Center.
R.R Penna. Lines
Date. 8-17-08.
Inst. Deflectometer
Records 1242-1268
Engine # 7204 Headed West
Bridge # 37 206' Riveted Pratt Truss.
Percentage Difference of Static Deflection
Speed Miles per Hour.
10
5
0
5
10
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
1251
1268
1259
1265
1261
1258
1257
1253
1263
1264
1267
1262
1266
1260


R.R- Penna
Date- 8-18-'08
Inst. - Deflec.
Records - 1269 - 1296
Engine #7027 Headed West.
Bridge #37 · 206' Riveted Pratt Truss.
Counter Balance Feet from Center.
W
E
10
5
0
5
10
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
Speed Miles per Hr.
0
10
20
30
40
50
60
70
1271
1269
1278
1290
1293
1291
1294
1264
1281
c
x


W
10
5
0
5
10
E
Counter Balance
Feet from Center
1302
1307
1308
R.R.- Penna.
Date - 8-19-08
Inst - Deflec
Records- 1297 - 1315
Engine #7204 Headed West.
Bridge #38 Outside Girder - 4 Track Girder 77' 10½"
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1308
1307
1302
Speed Miles per Hour.
0
10
20
30
40
50
60
70

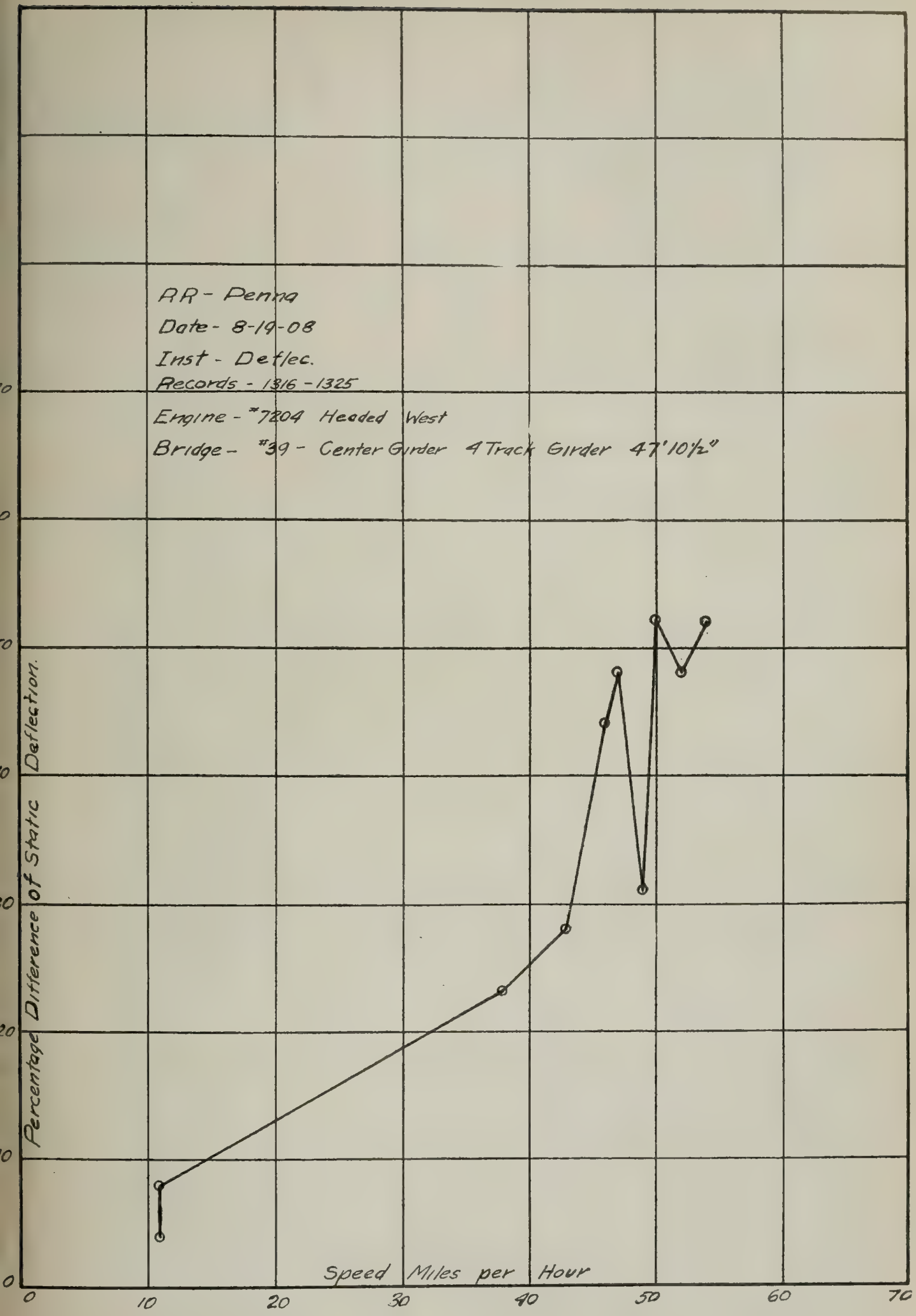
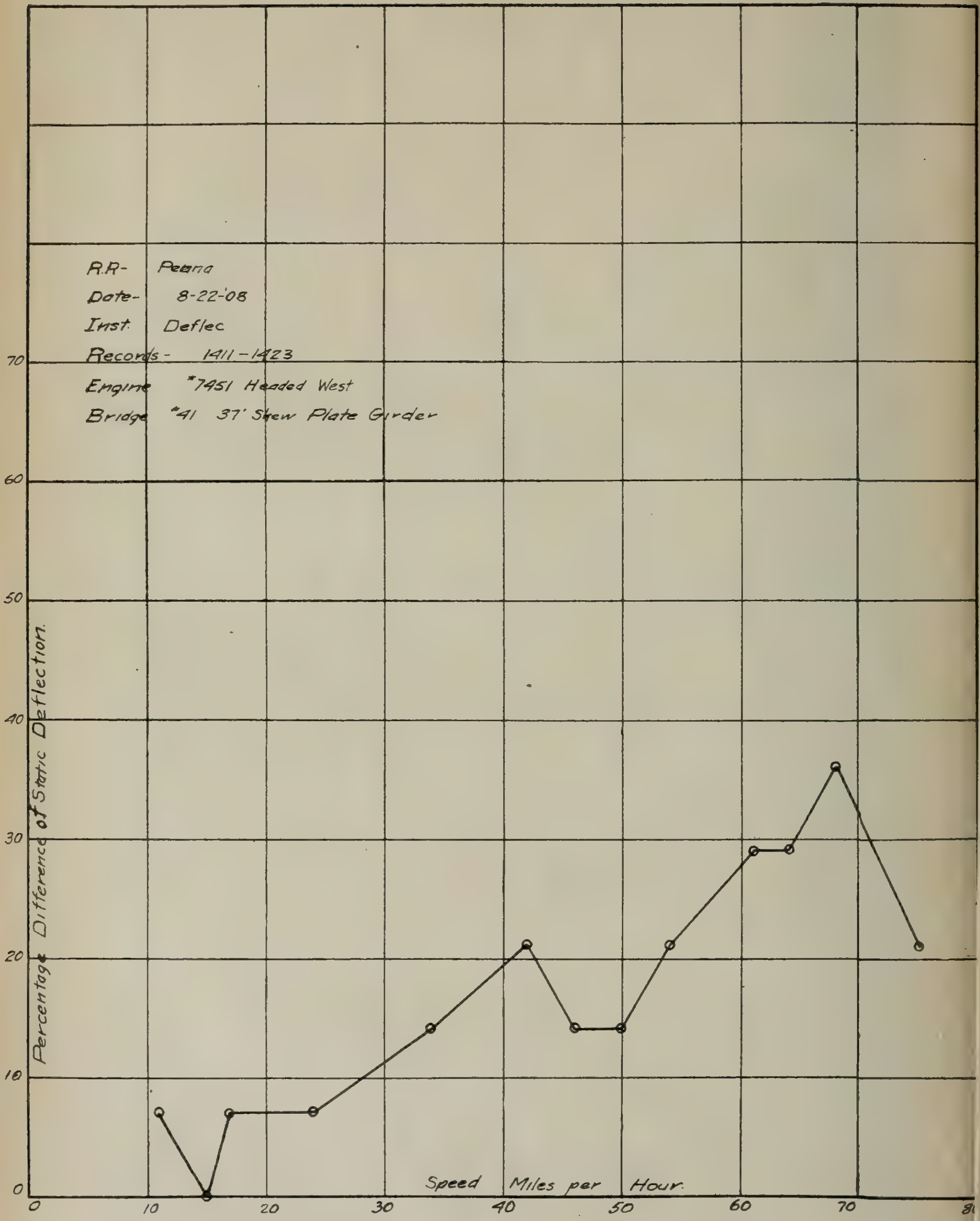
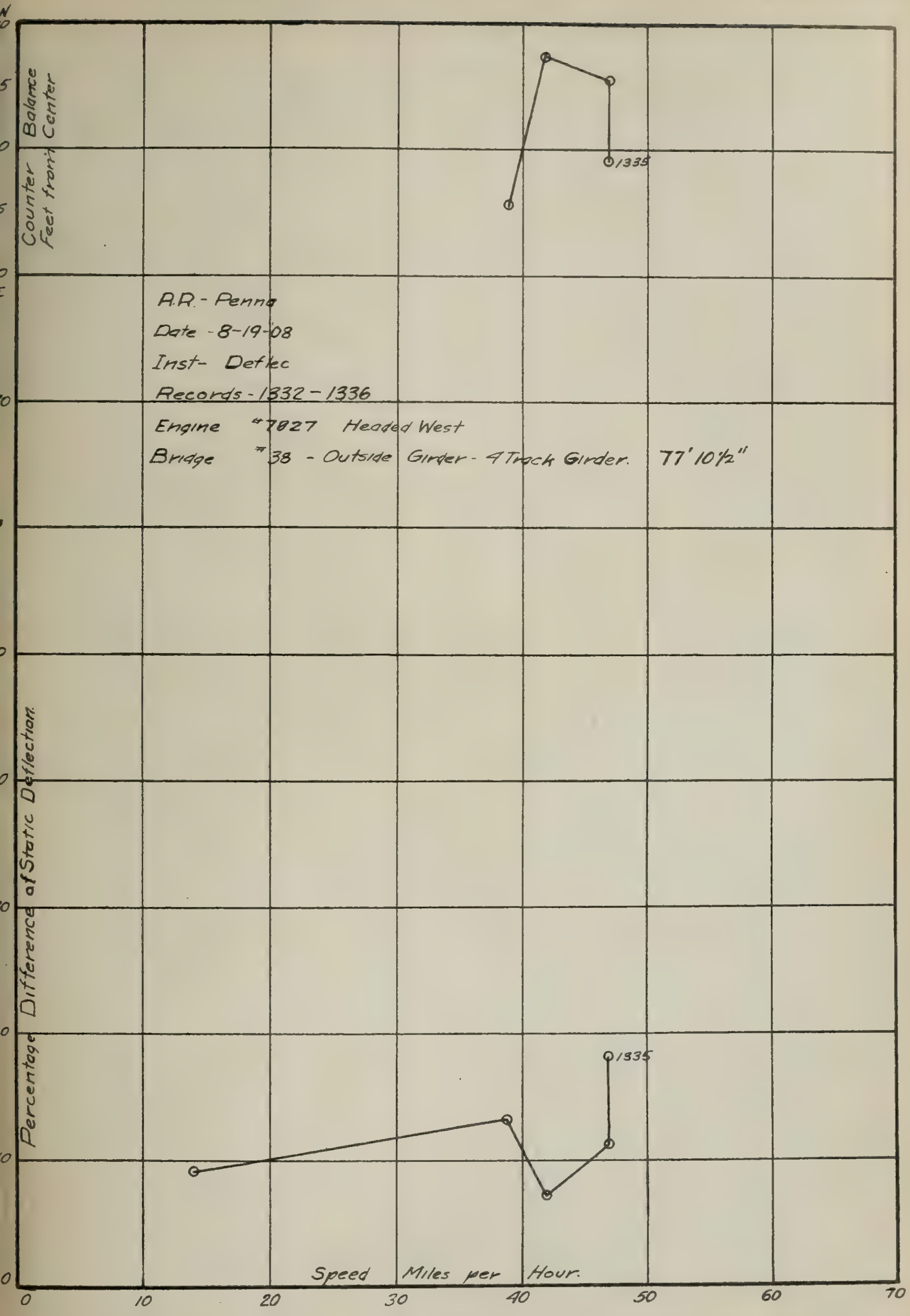
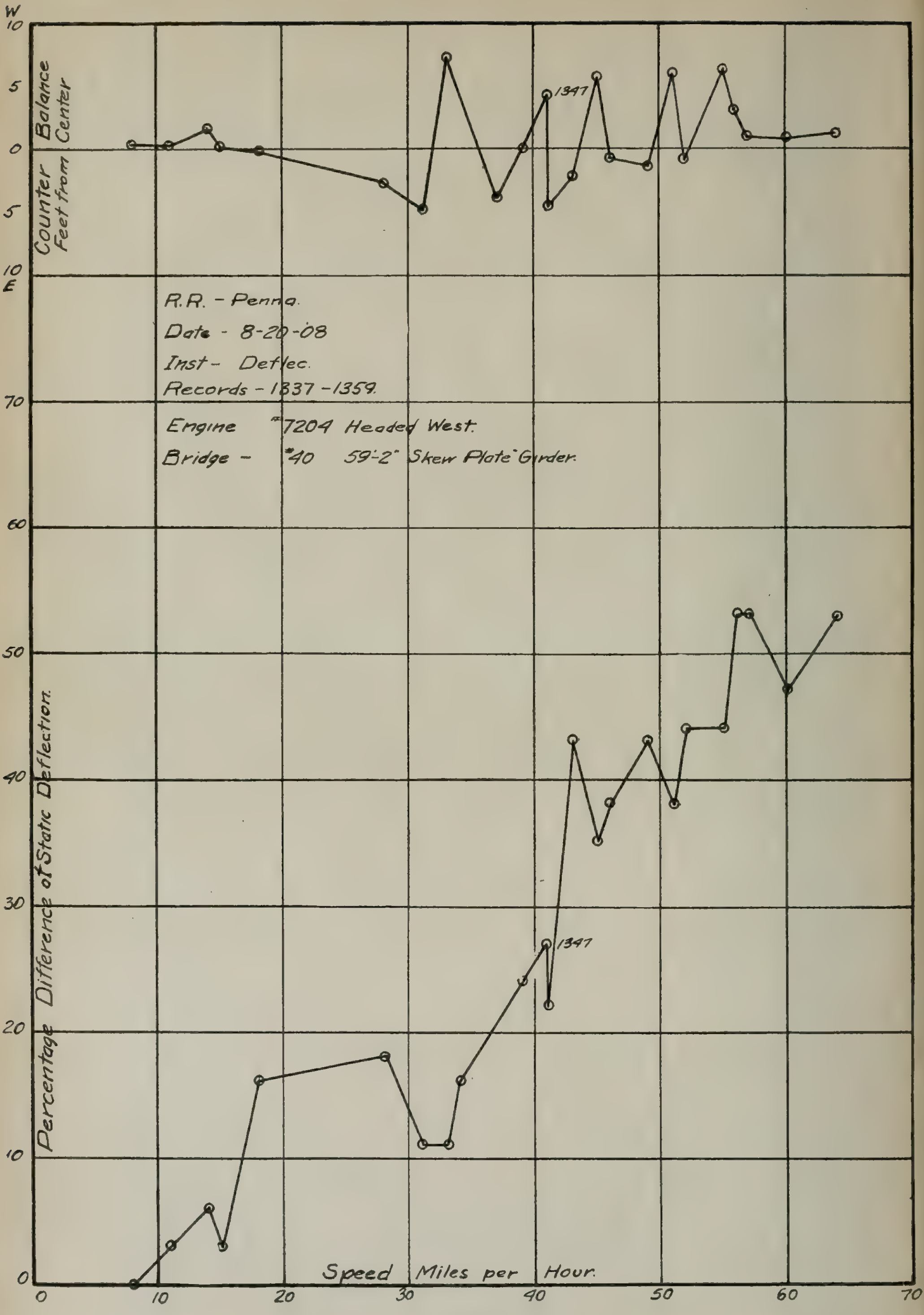
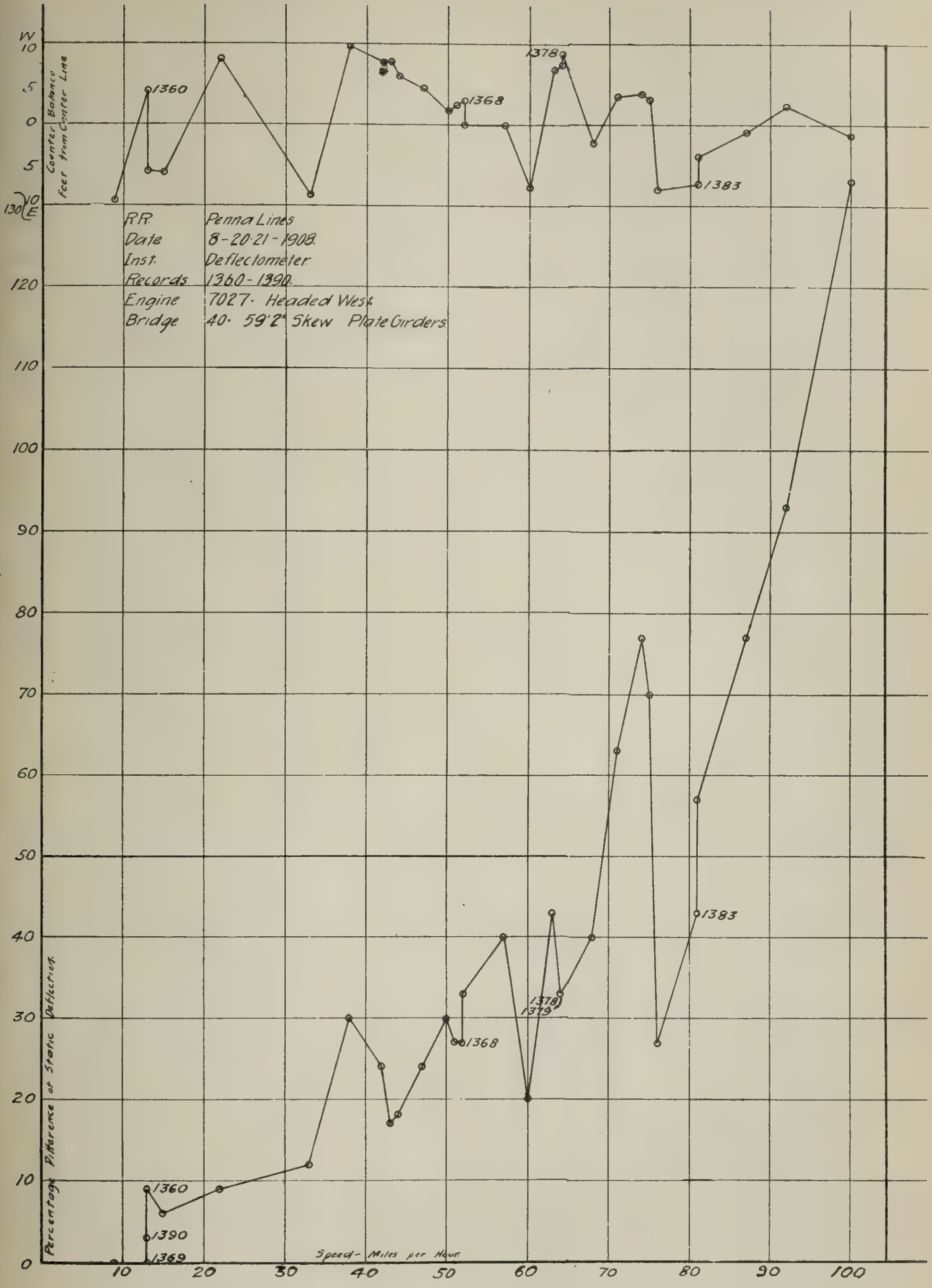

RR - Penna
Date - 8-19-08
Inst - Deflec.
Records - 1316 - 1325
Engine - #7204 Headed West
Bridge - #39 - Center Girder 4 Track Girder 47'10½"
Percentage Difference of Static Deflection.
Speed Miles per Hour
0
10
20
30
40
50
60
70
0
0
20
0
0
0
0
0

PLATE III—bh.


R.R- Penna
Date- 8-22-08
Inst. Deflec
Records- 1411-1423
Engine *7451 Headed West
Bridge *41 37' Skew Plate Girder
Percentage Difference of Static Deflection.
Speed Miles per Hour.
0
10
20
30
40
50
60
70


Counter Balance
Feet from Center
1335
A.R. - Penna
Date - 8-19-08
Inst- Deflec
Records - 1332 - 1336
Engine #7027 Headed West
Bridge #38 - Outside Girder - 4 Track Girder. 77' 10½"
Percentage Difference of Static Deflection
1335
Speed Miles per Hour.
0
10
20
30
40
50
60
70


W
10
5
0
5
10
E
Counter Balance
Feet from Center
1347
R.R. - Penna.
Date - 8-20-08
Inst - Deflec.
Records - 1337 - 1359.
Engine #7204 Headed West.
Bridge - #40 59'-2" Skew Plate Girder.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1347
Speed Miles per Hour.
0
10
20
30
40
50
60
70


W
10
5
0
5
10
E
130
Counter Balance Feet from Center Line
R.R. Penna Lines
Date 8-20-21-1908.
Inst. Deflectometer
Records 1360-1390.
Engine 7027. Headed West
Bridge 40. 59'2" Skew Plate Girders
120
110
100
90
80
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1360
1368
1378
1383
1378
1379
1390
1369
Speed—Miles per Hour.
10
20
30
40
50
60
70
80
90
100

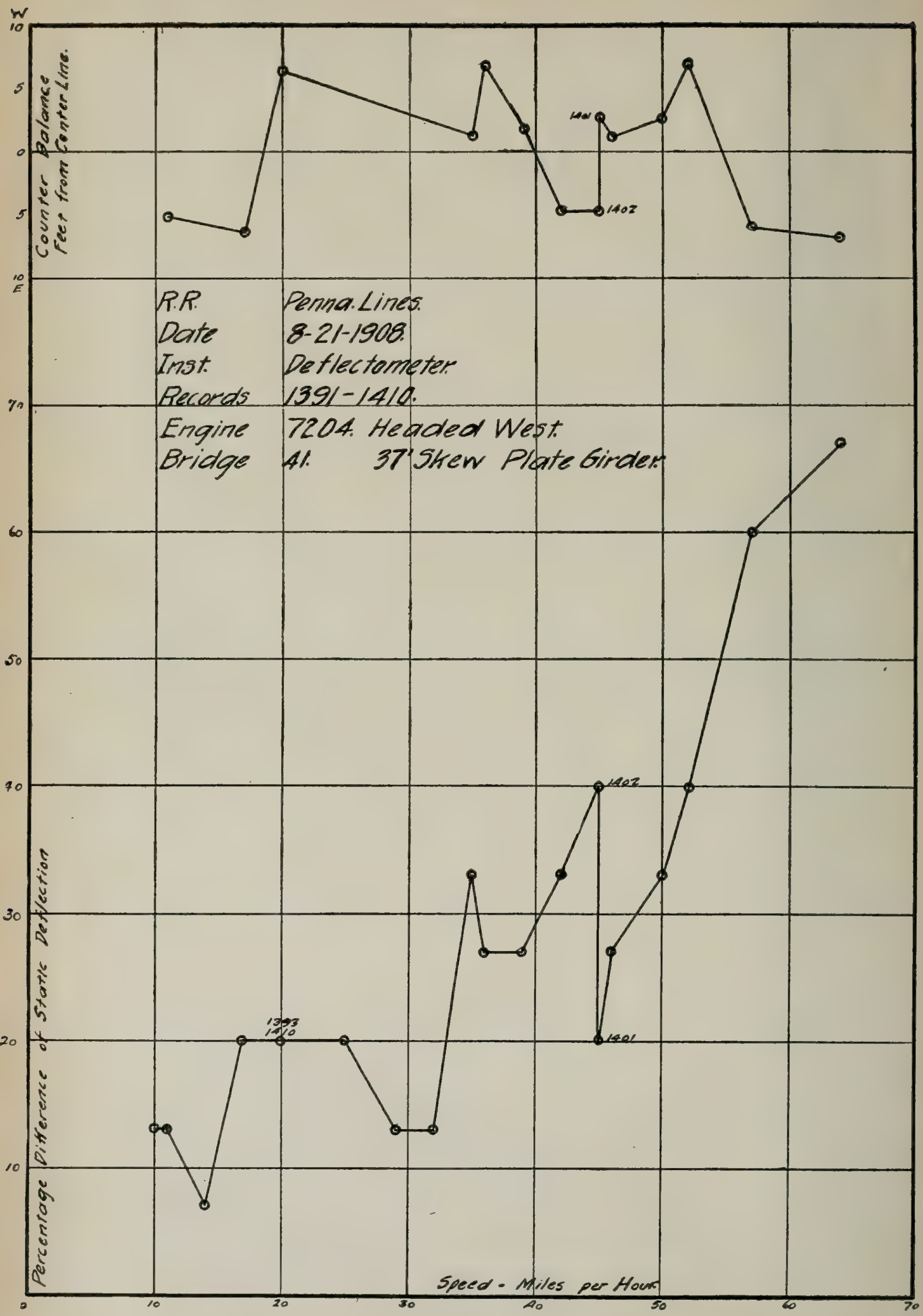
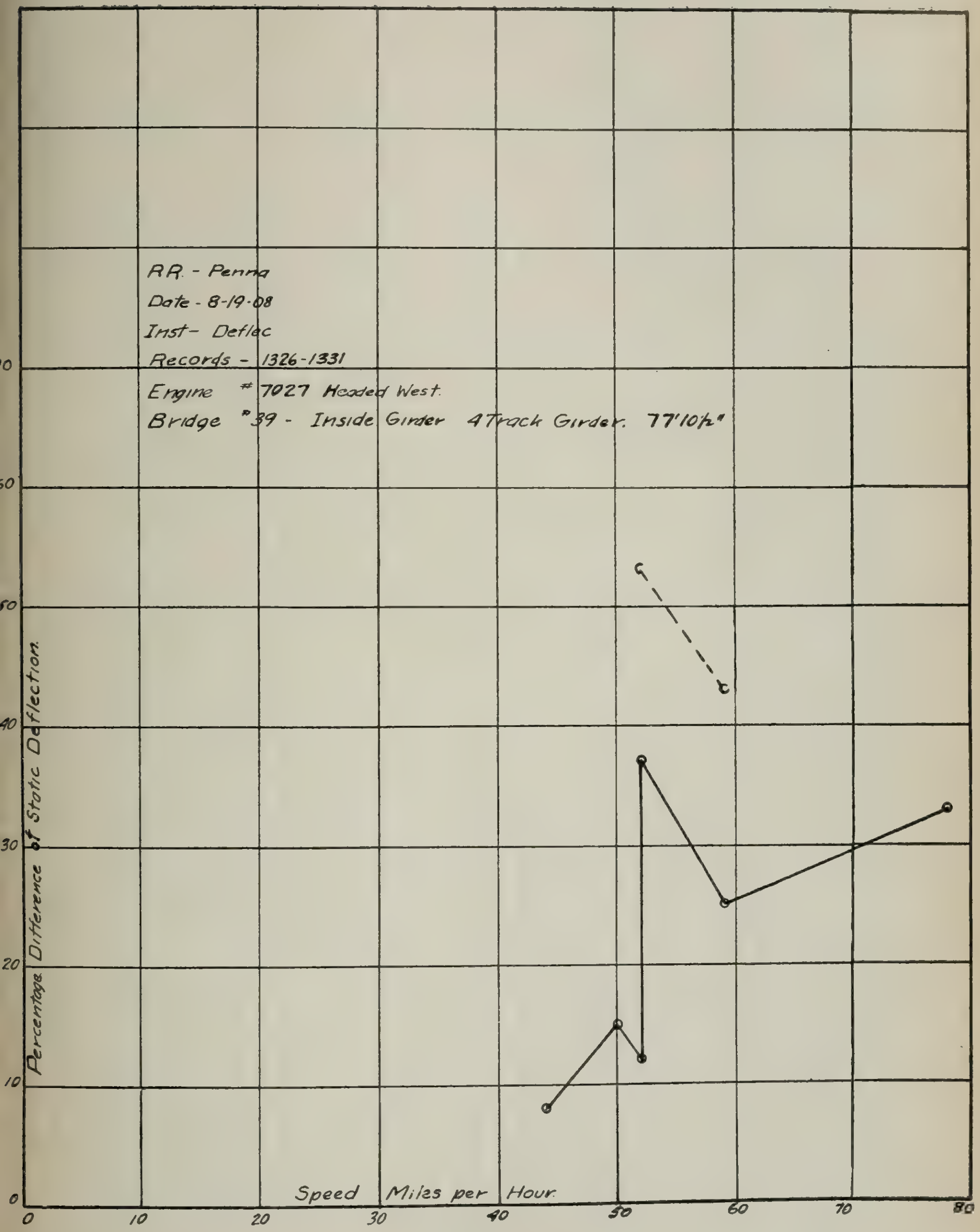
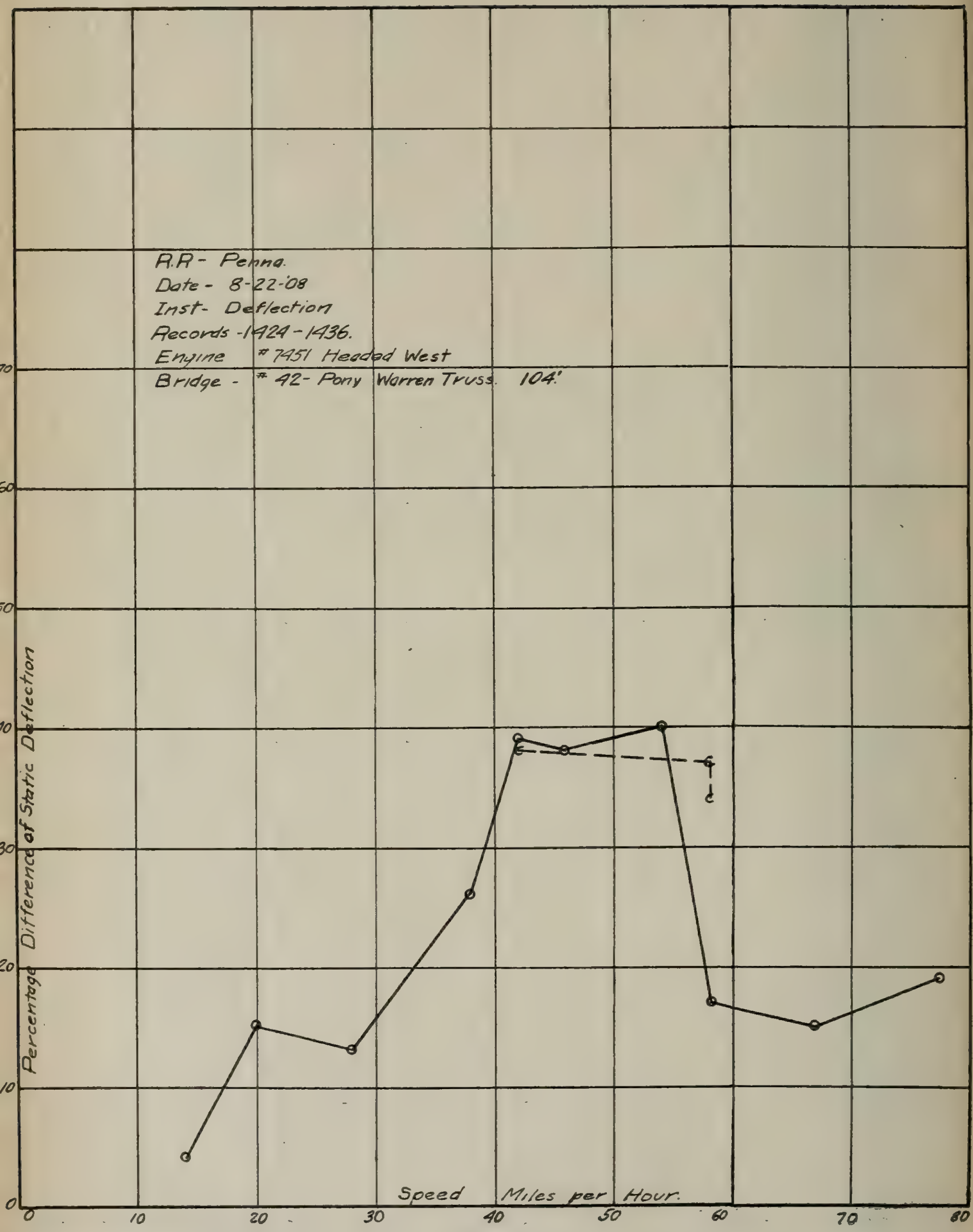

W
10
5
0
5
10
E
Counter Balance
Feet from Center Line.
1401
1402
R.R. Penna. Lines.
Date 8-21-1908.
Inst. Deflectometer.
Records 1391-1410.
Engine 7204. Headed West.
Bridge 41. 37' Skew Plate Girder.
70
60
50
40
30
20
10
0
1402
1393
1410
1401
Percentage Difference of Static Deflection
Speed - Miles per Hour.
10
20
30
40
50
60
70

PLATE III—bm.



RR. - Penna
Date - 8-19-08
Inst- Deflec
Records - 1326-1331
Engine #7027 Headed West.
Bridge #39 - Inside Girder 4 Track Girder. 77'10½"
Percentage Difference of Static Deflection.
Speed Miles per Hour.
0
10
20
30
40
50
60
70
80
0
10
20
30
40

PLATE III—bn.


R.R - Penna.
Date - 8-22-08
Inst - Deflection
Records - 1424 - 1436.
Engine #7451 Headed West
Bridge - #42 - Pony Warren Truss. 104'
Percentage Difference of Static Deflection
Speed Miles per Hour.
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80

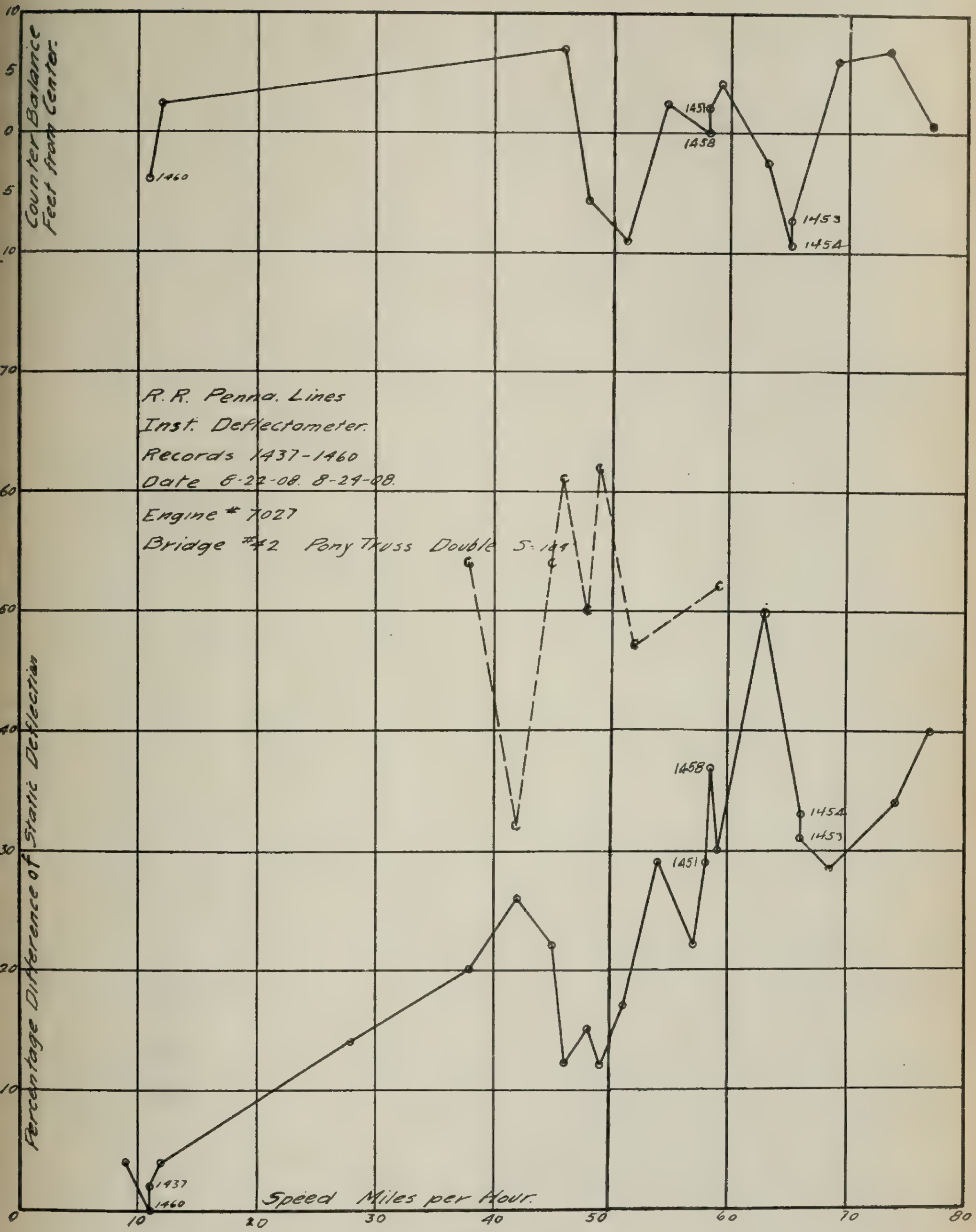
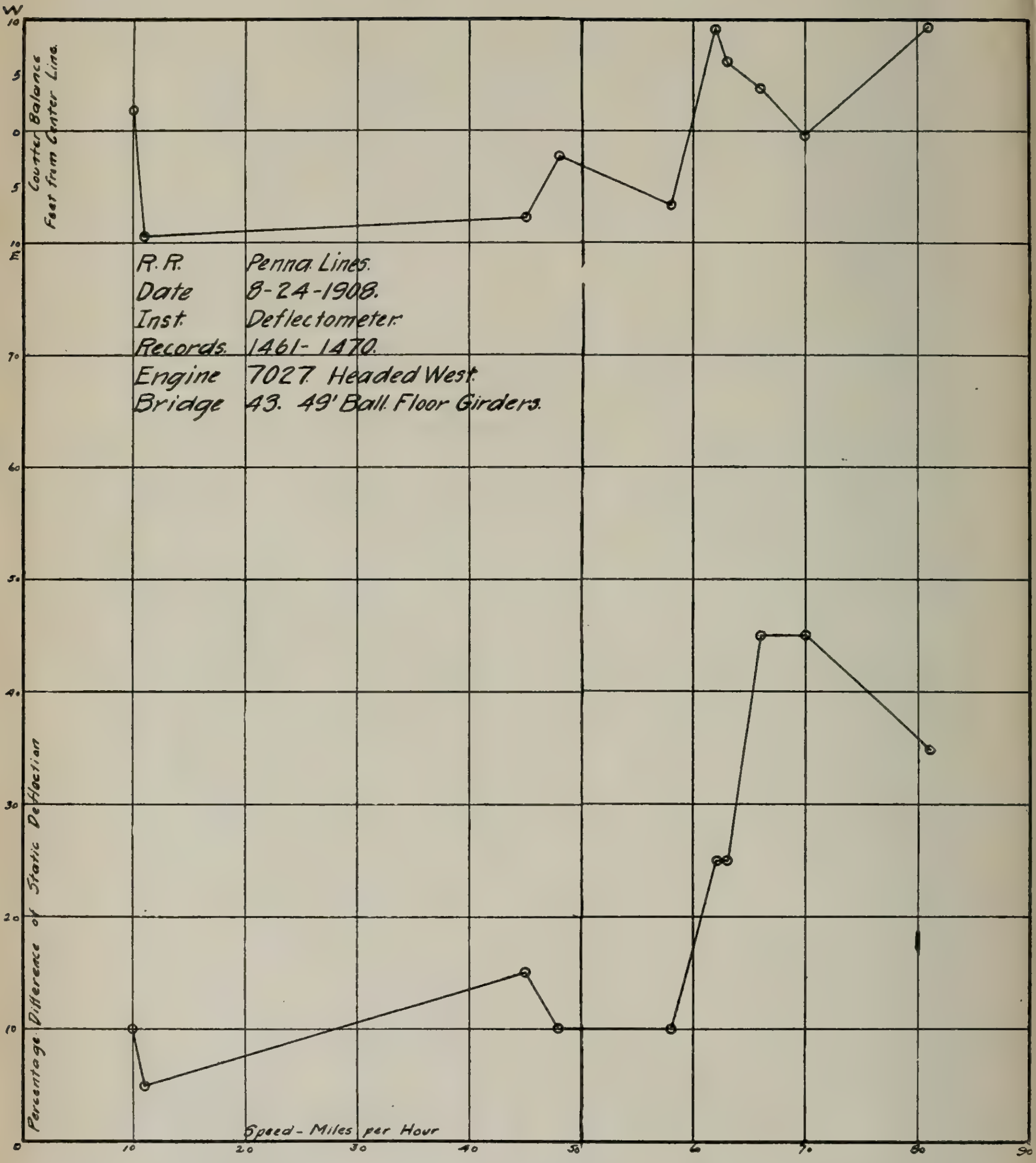
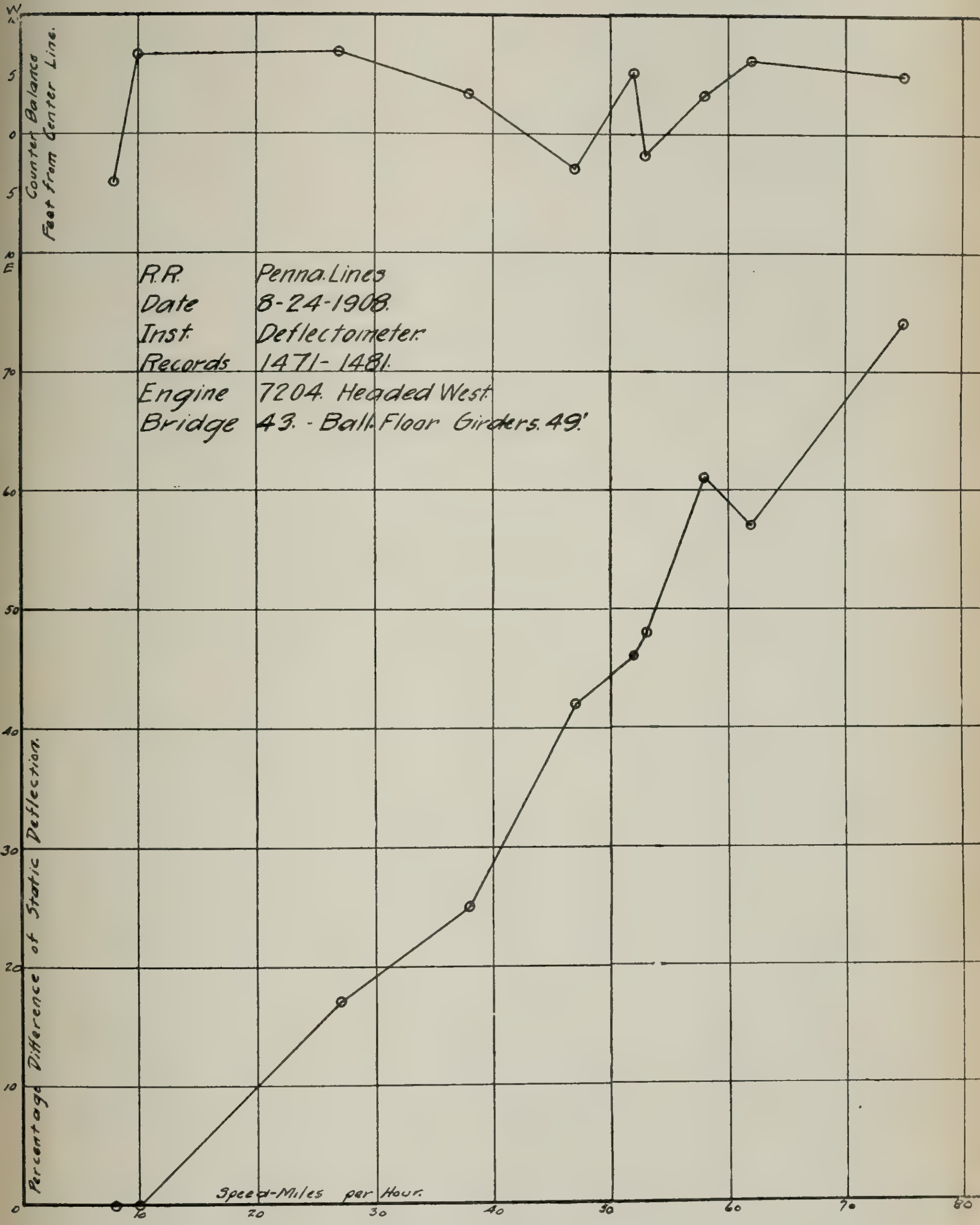
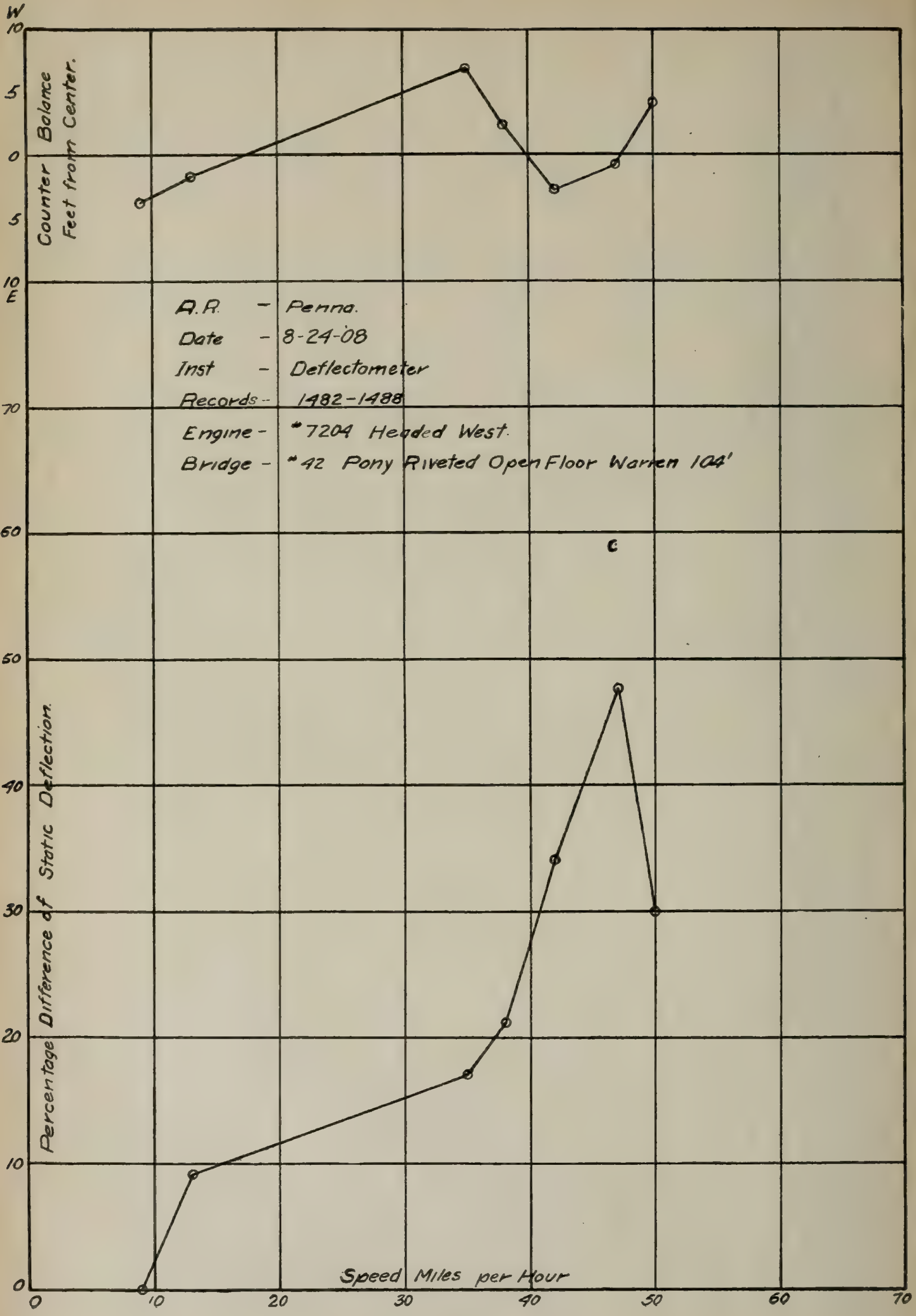
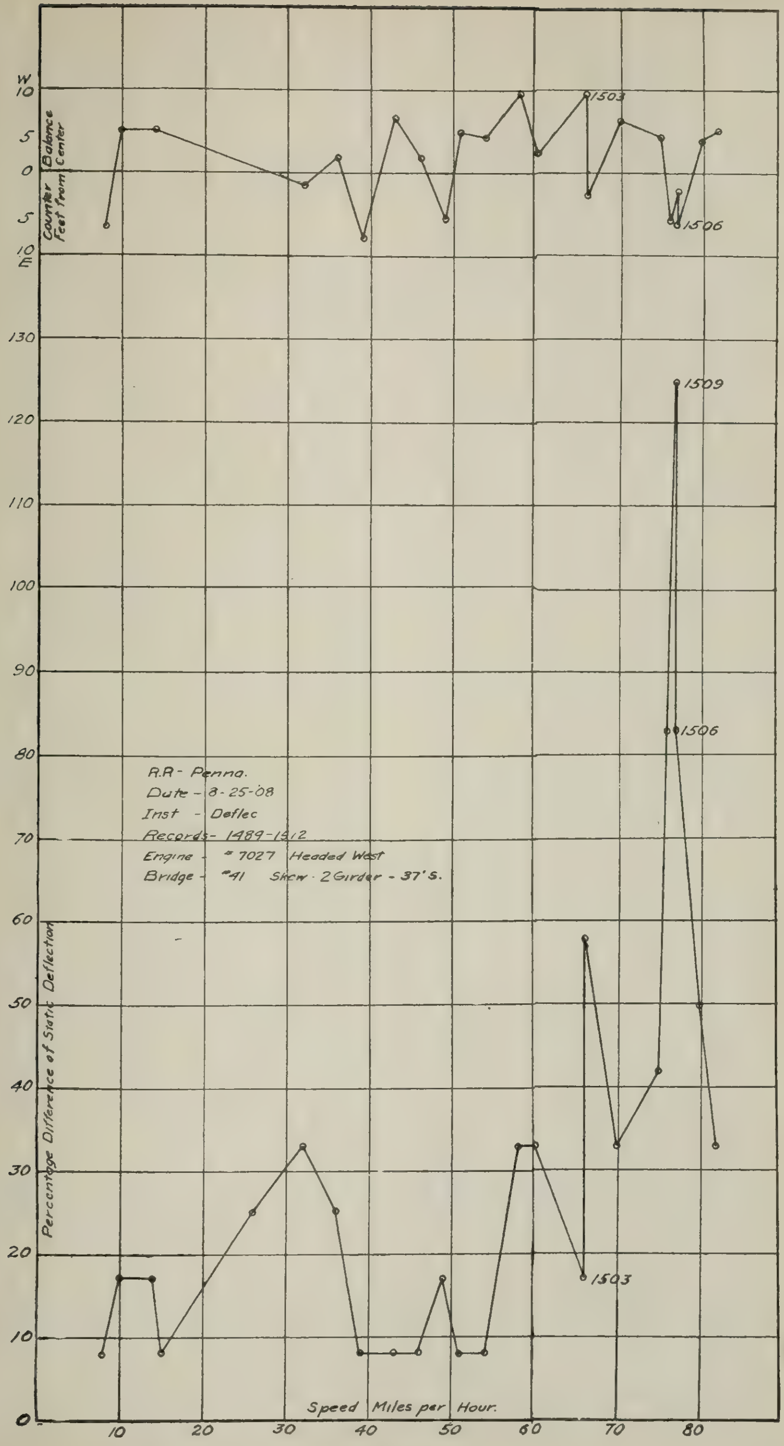

Counter Balance
Feet from Center.
10
5
0
5
10
70
60
50
40
30
20
10
0
1460
1451
1458
1453
1454
R.R. Penna. Lines
Inst. Deflectometer.
Records 1437-1460
Date 8-22-08. 8-24-08.
Engine # 7027
Bridge #42 Pony Truss Double S=144
Percentage Difference of Static Deflection
1458
1454
1453
1451
1437
1460
Speed Miles per Hour.
0
10
20
30
40
50
60
70
80

PLATE III—bp.

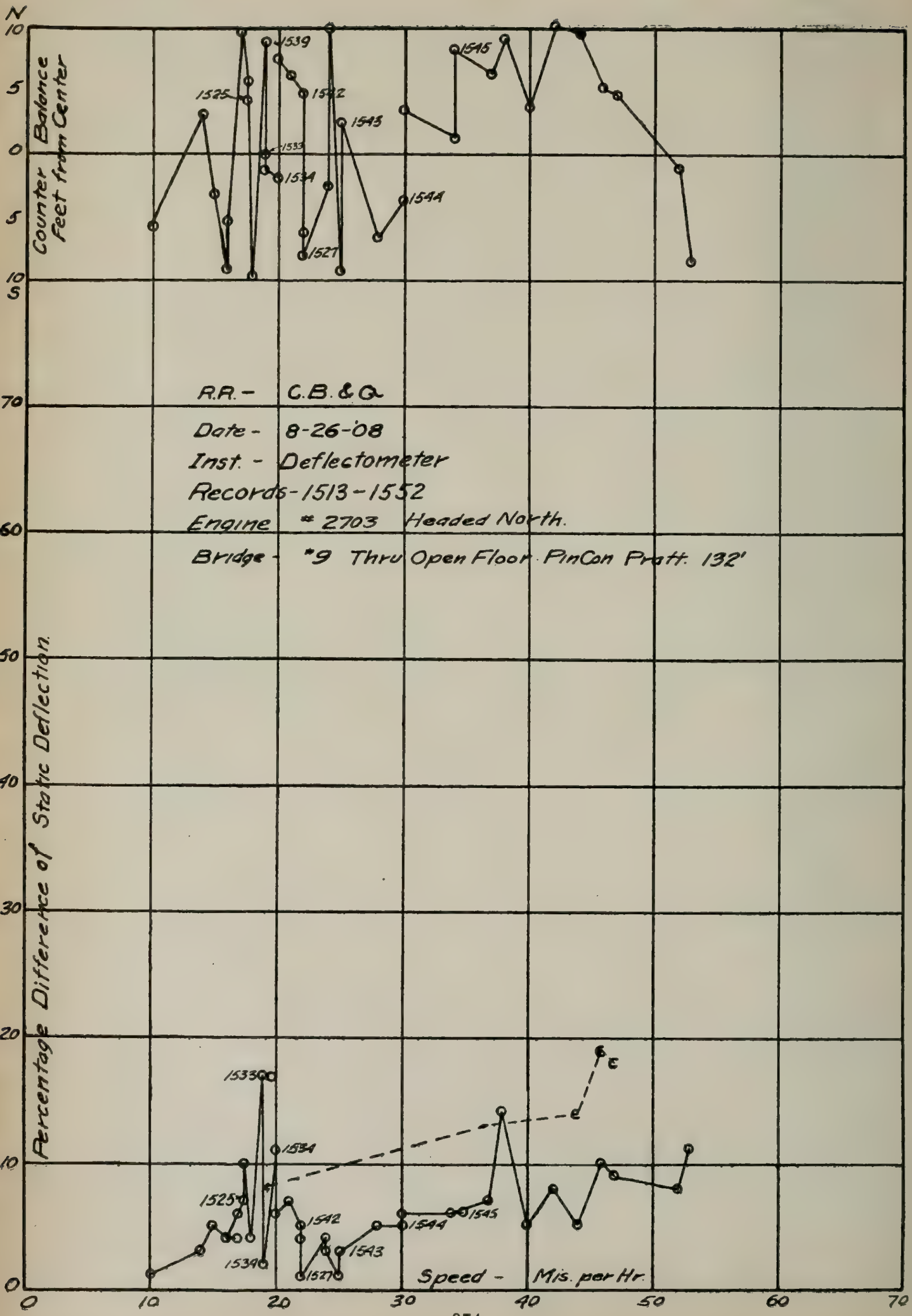

W
10
5
0
5
10
E
Counter Balance
Feet from Center Line.
R.R. Penna. Lines.
Date 8-24-1908.
Inst. Deflectometer.
Records. 1461-1470.
Engine 7027. Headed West.
Bridge 43. 49' Ball. Floor Girders.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
Speed - Miles per Hour
10
20
30
40
50
60
70
80
90


W
10
5
0
5
10
E
Counter Balance
Feet from Center Line.
R.R. Penna. Lines
Date 8-24-1908.
Inst. Deflectometer.
Records 1471-1481.
Engine 7204. Headed West.
Bridge 43. - Ball. Floor Girders. 49'.
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
Speed-Miles per Hour.
10
20
30
40
50
60
70
80


W
10
5
0
5
10
E
Counter Balance
Feet from Center.
A.R. - Penna.
Date - 8-24-08
Inst - Deflectometer
Records - 1482-1488
Engine - #7204 Headed West
Bridge - #42 Pony Riveted Open Floor Warren 104'
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
Speed Miles per Hour
0
10
20
30
40
50
60
70



R.R - Penna.
Date - 8-25-08
Inst - Deflec
Records - 1489-1512
Engine - #7027 Headed West
Bridge - #41 Skew - 2 Girder - 37'S.


N
10
5
0
5
10
S
Counter Balance
Feet from Center
1525
1539
1542
1533
1534
1527
1545
1543
1544
R.R. - C.B.&Q.
Date - 8-26-08
Inst. - Deflectometer
Records - 1513-1552
Engine #2703 Headed North.
Bridge - #9 Thru Open Floor PinCon Pratt. 132'
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
1533
1534
1525
1542
1539
1527
1543
1544
1545
E
Speed - Mis. per Hr.
0
10
20
30
40
50
60
70

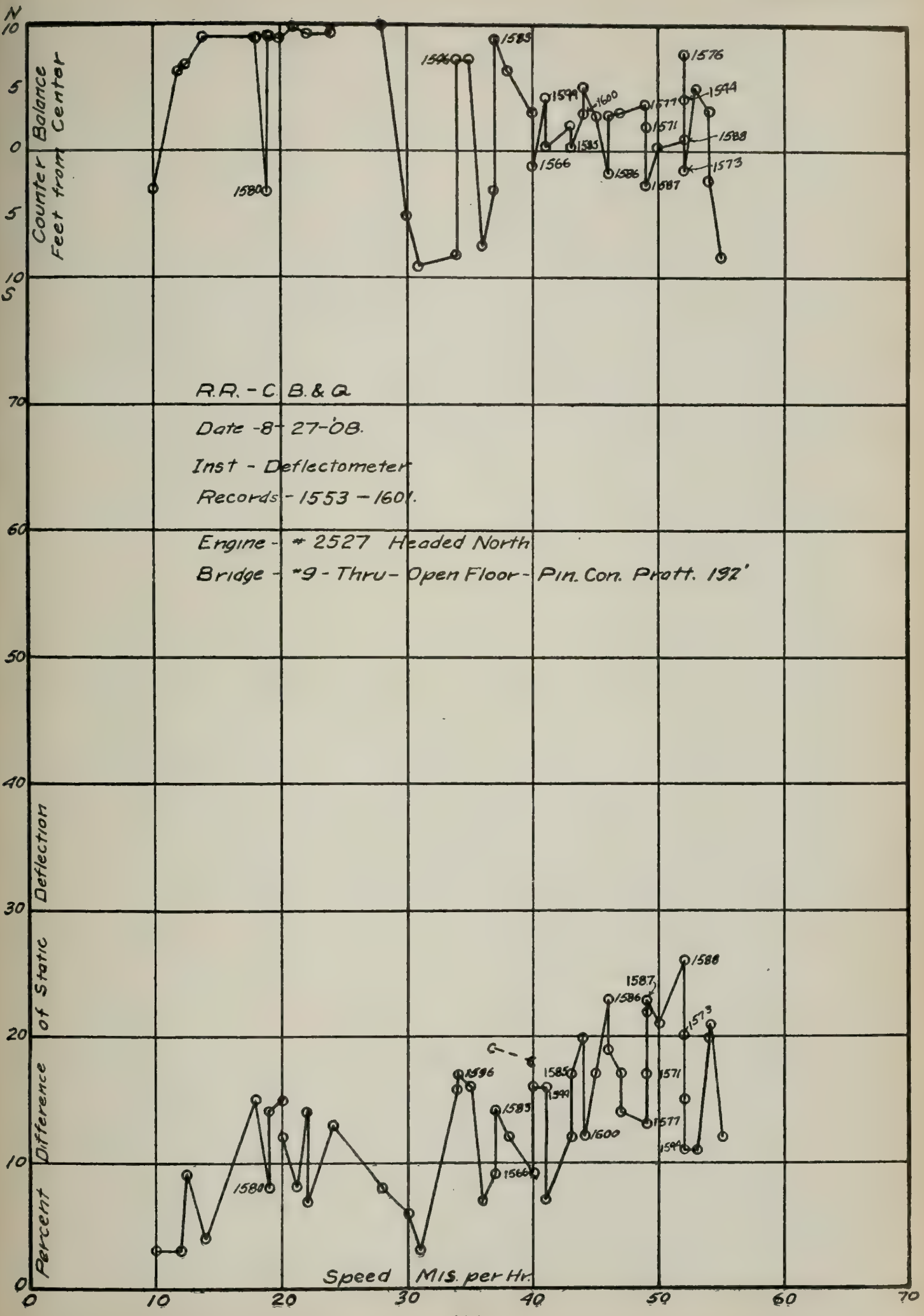
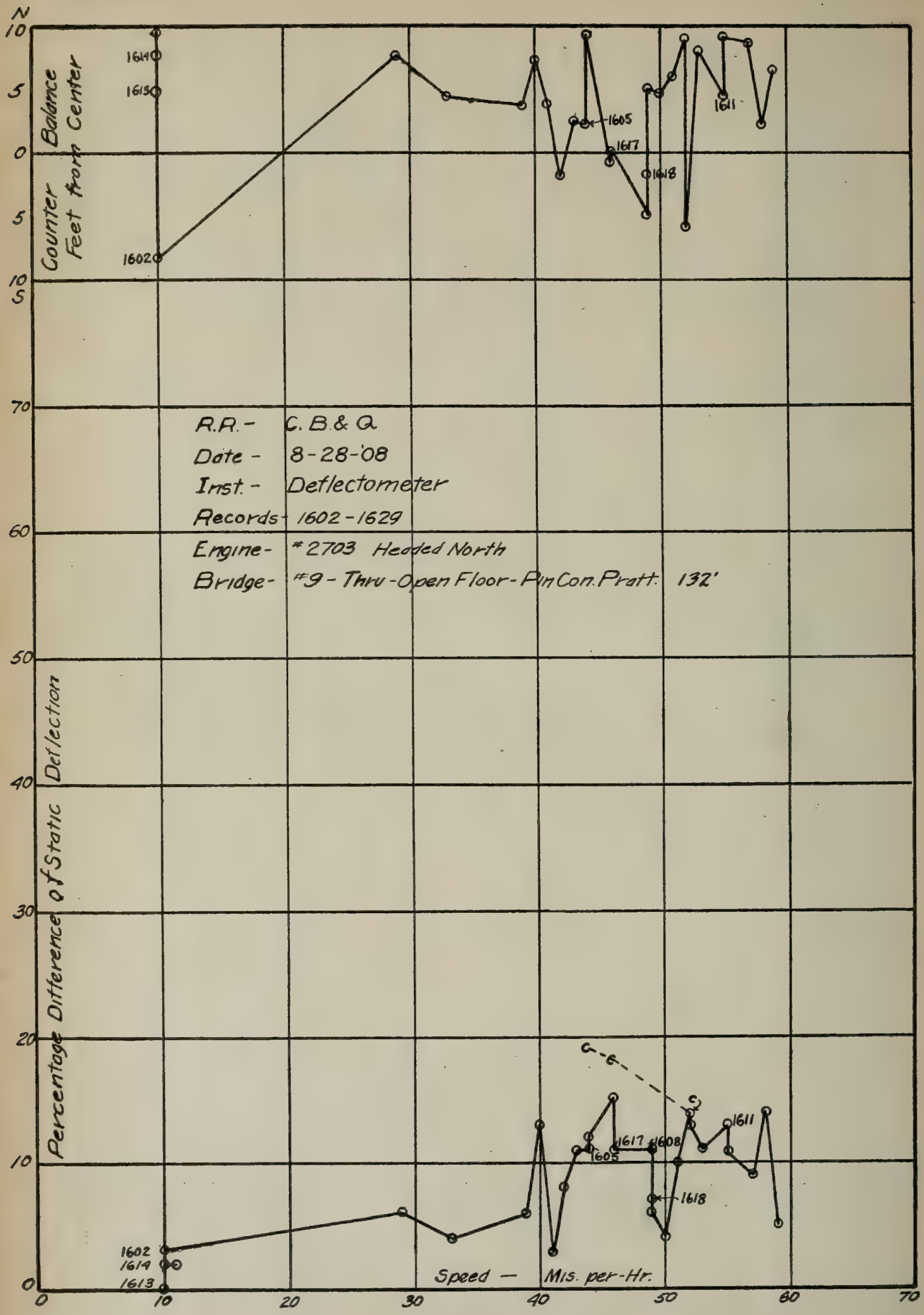
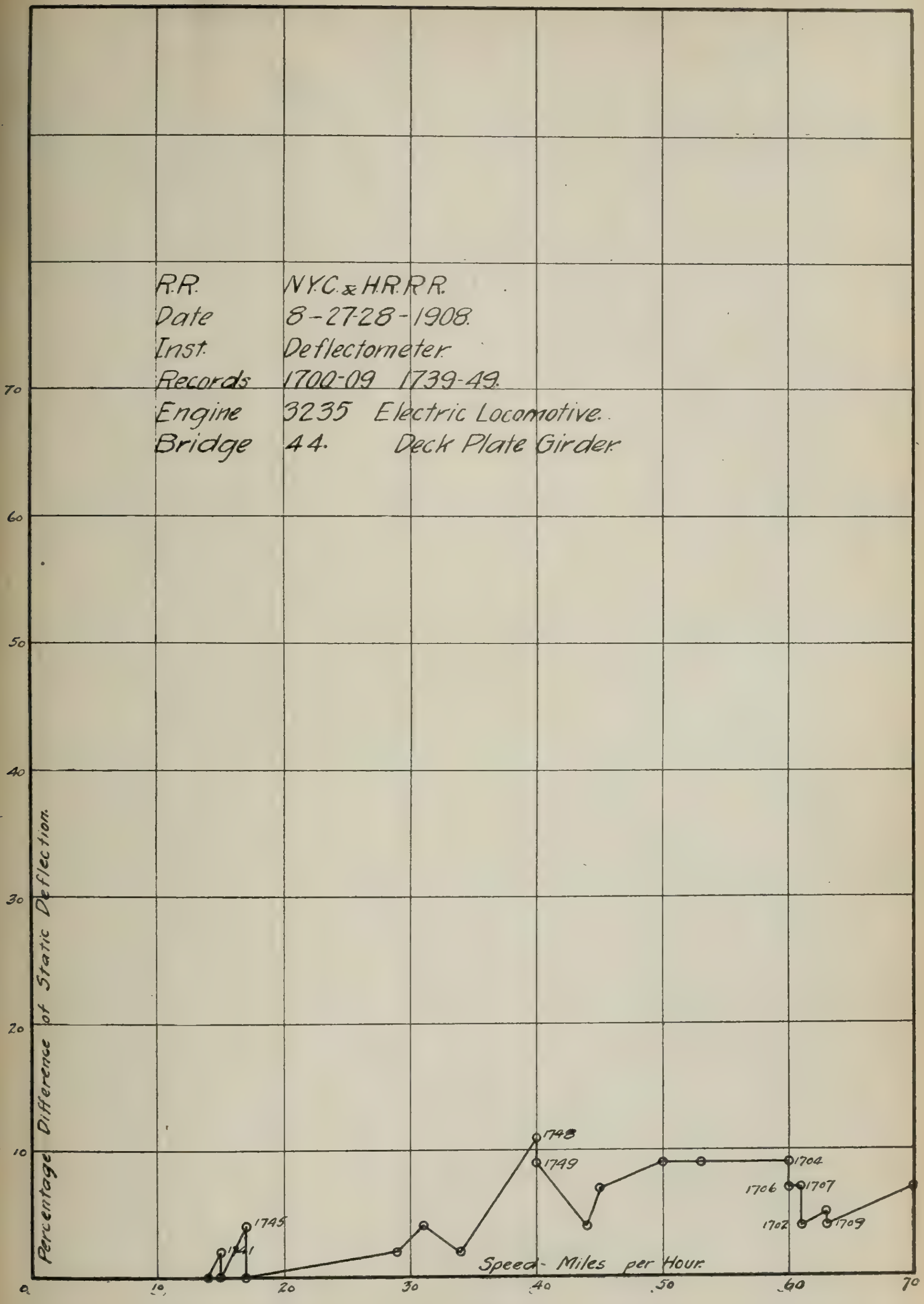
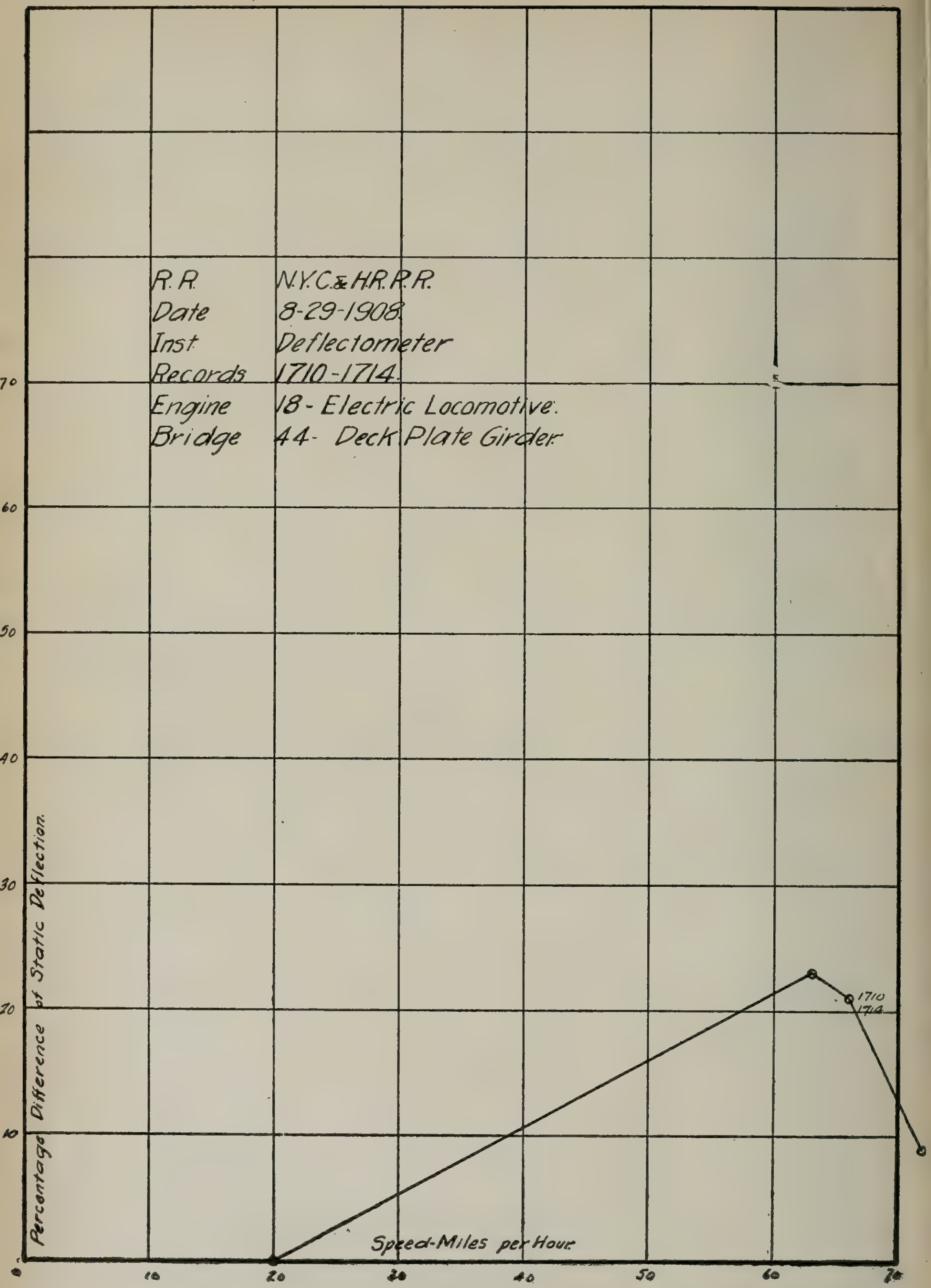
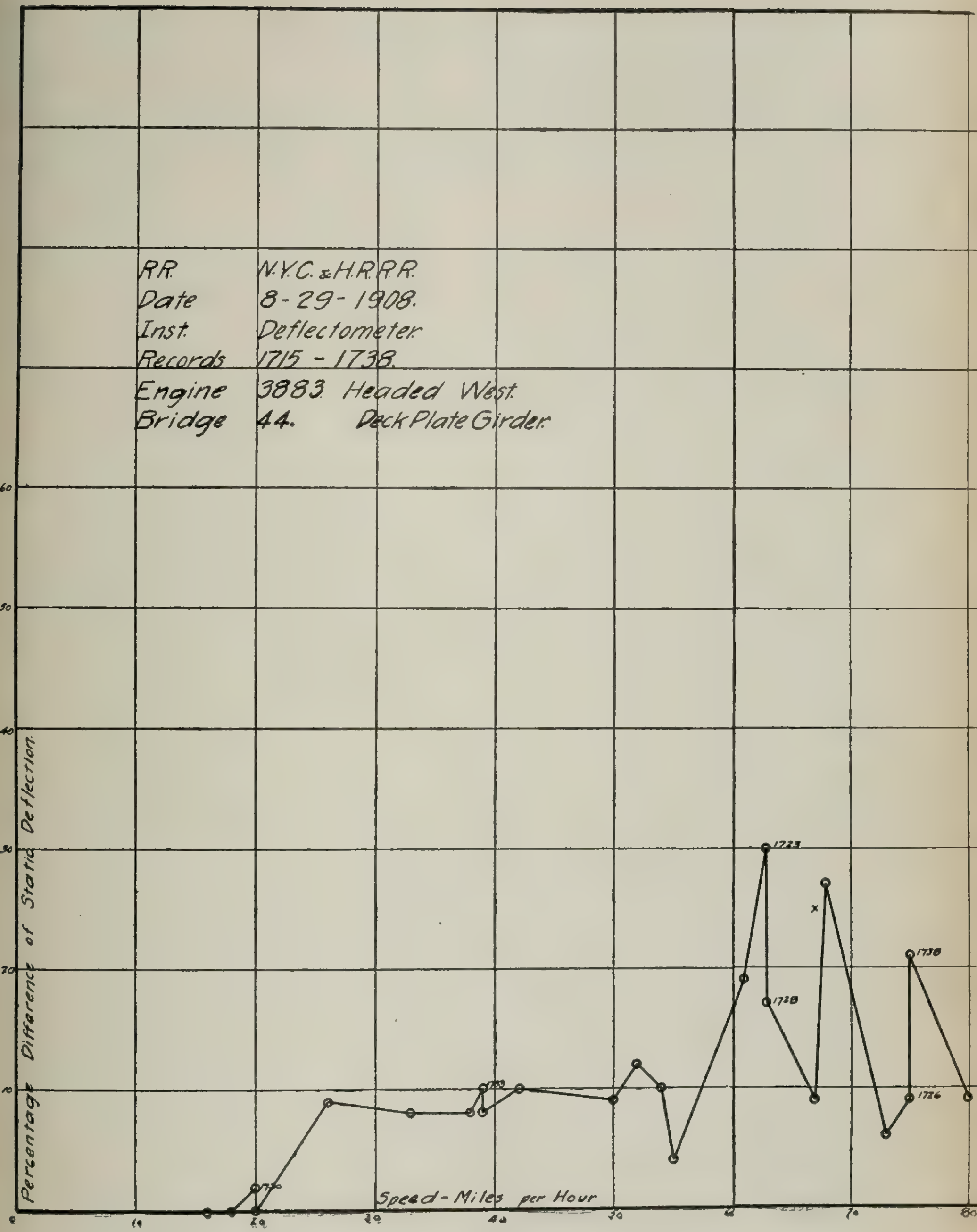

R.R. - C. B. & Q.
Date - 8 - 27 - 08.
Inst - Deflectometer
Records - 1553 - 1601.
Engine - # 2527 Headed North
Bridge - #9 - Thru - Open Floor - Pin. Con. Pratt. 192'
Counter Balance Feet from Center
N
S
Percent Difference of Static Deflection
Speed Mls. per Hr.
0
10
20
30
40
50
60
70
5
1580
1596
1583
1576
1599
1600
1577
1544
1571
1588
1585
1566
1586
1587
1573
1600
1577
1599
G

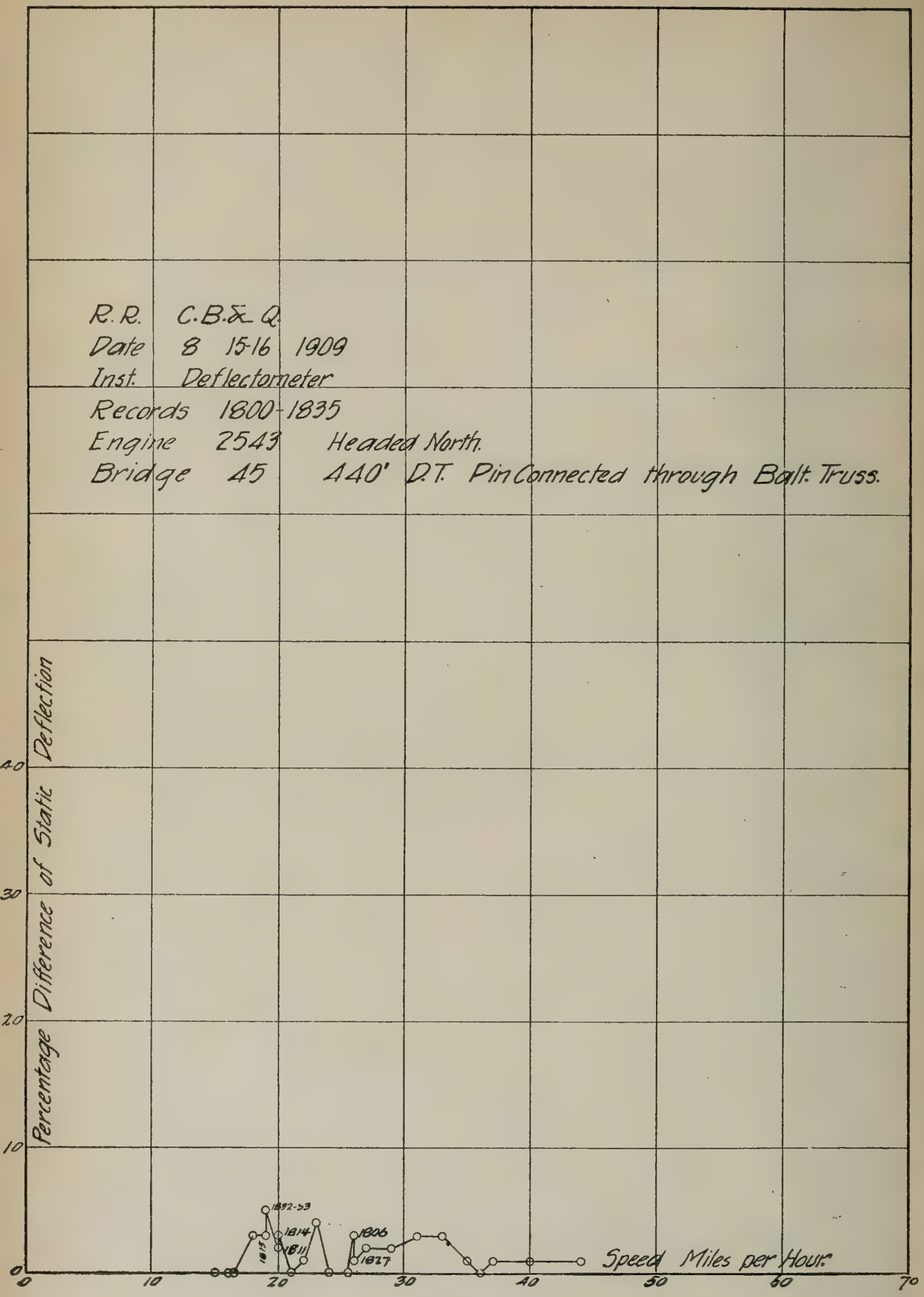
PLATE III—bv.


N
10
5
0
5
10
S
Counter Balance
Feet from Center
1614
1615
1602
1605
1617
1618
1611
70
60
50
40
30
20
10
0
Percentage Difference of Static Deflection
R.R.- C.B.& Q.
Date - 8-28-'08
Inst.- Deflectometer
Records- 1602-1629
Engine- #2703 Headed North
Bridge- #9-Thru-Open Floor-Pin Con. Pratt. 132'
1602
1614
1613
1605
1617
1608
1618
1611
Speed — Mis. per-Hr.
0
10
20
30
40
50
60
70


R.R. NY.C.&H.R.R.R.
Date 8-27-28-1908.
Inst. Deflectometer.
Records 1700-09 1739-49.
Engine 3235 Electric Locomotive.
Bridge 44. Deck Plate Girder.
Percentage Difference of Static Deflection.
Speed - Miles per Hour.
0
10
20
30
40
50
60
70
1741
1745
1748
1749
1704
1706
1707
1702
1709


R.R. N.Y.C.&H.R.R.R.
Date 8-29-1908.
Inst. Deflectometer
Records 1710-1714.
Engine 18 - Electric Locomotive.
Bridge 44- Deck Plate Girder.
Percentage Difference of Static Deflection.
Speed-Miles per Hour.
1710
1714
0
10
20
30
40
50
60
70
10
20
30
40
50
60
70


RR. N.Y.C. & H.R.R.R.
Date 8-29-1908.
Inst. Deflectometer.
Records 1715 - 1738.
Engine 3883 Headed West.
Bridge 44. Deck Plate Girder.
Percentage Difference of Static Deflection.
Speed - Miles per Hour
0
10
20
30
40
50
60
70
80
10
20
30
40
50
60
1723
1728
1738
1726
x


R.R. C.B.&Q.
Date 8 15-16 1909
Inst. Deflectometer
Records 1800-1835
Engine 2543 Headed North.
Bridge 45 440' D.T. Pin Connected through Balt. Truss.
Percentage Difference of Static Deflection
40
30
20
10
0
1832-33
1814
1811
1815
1806
1827
Speed Miles per Hour.
0
10
20
30
40
50
60
70

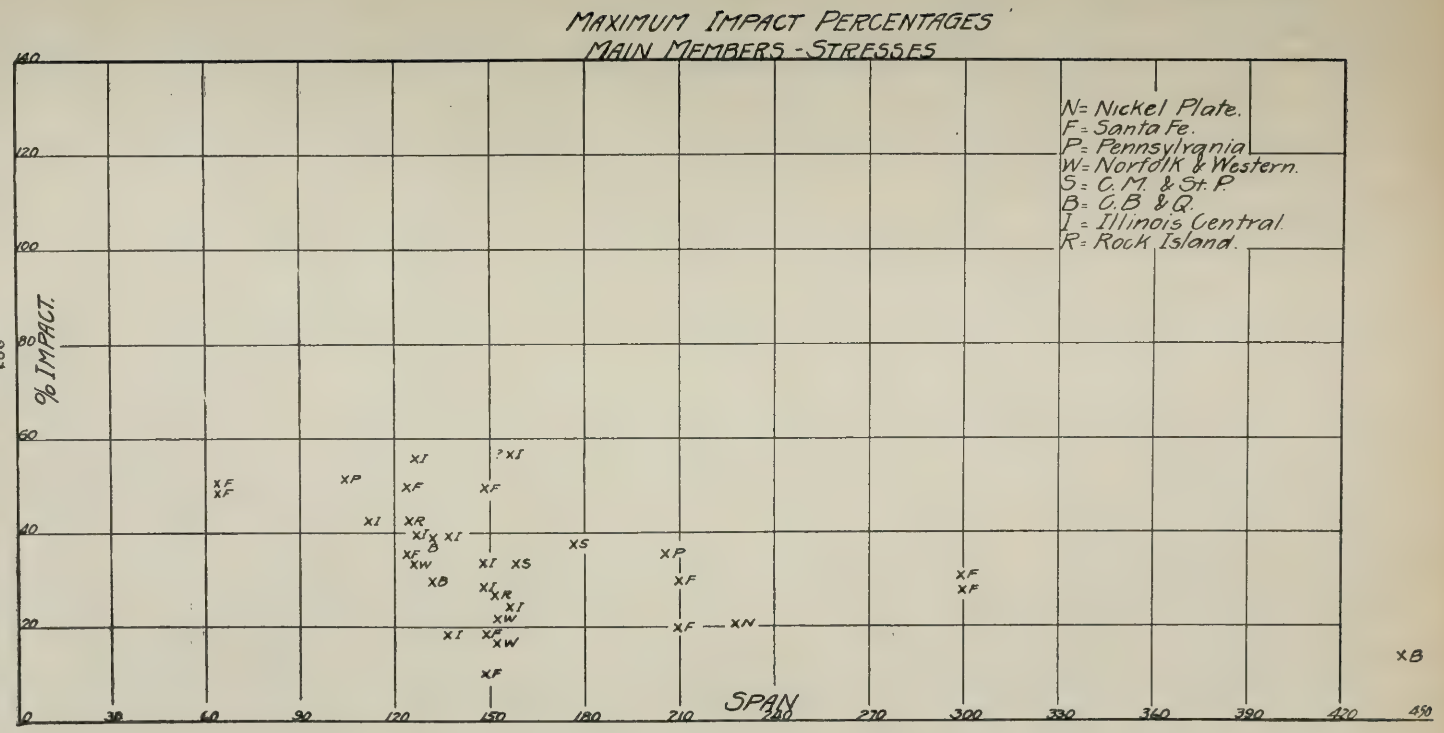

MAXIMUM IMPACT PERCENTAGES
MAIN MEMBERS - STRESSES
N= Nickel Plate.
F= Santa Fe.
P= Pennsylvania
W= Norfolk & Western.
S= C.M. & St. P.
B= C.B. & Q.
I = Illinois Central.
R= Rock Island.
% IMPACT.
SPAN
0
20
40
60
80
100
120
140
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450

PLATE V.

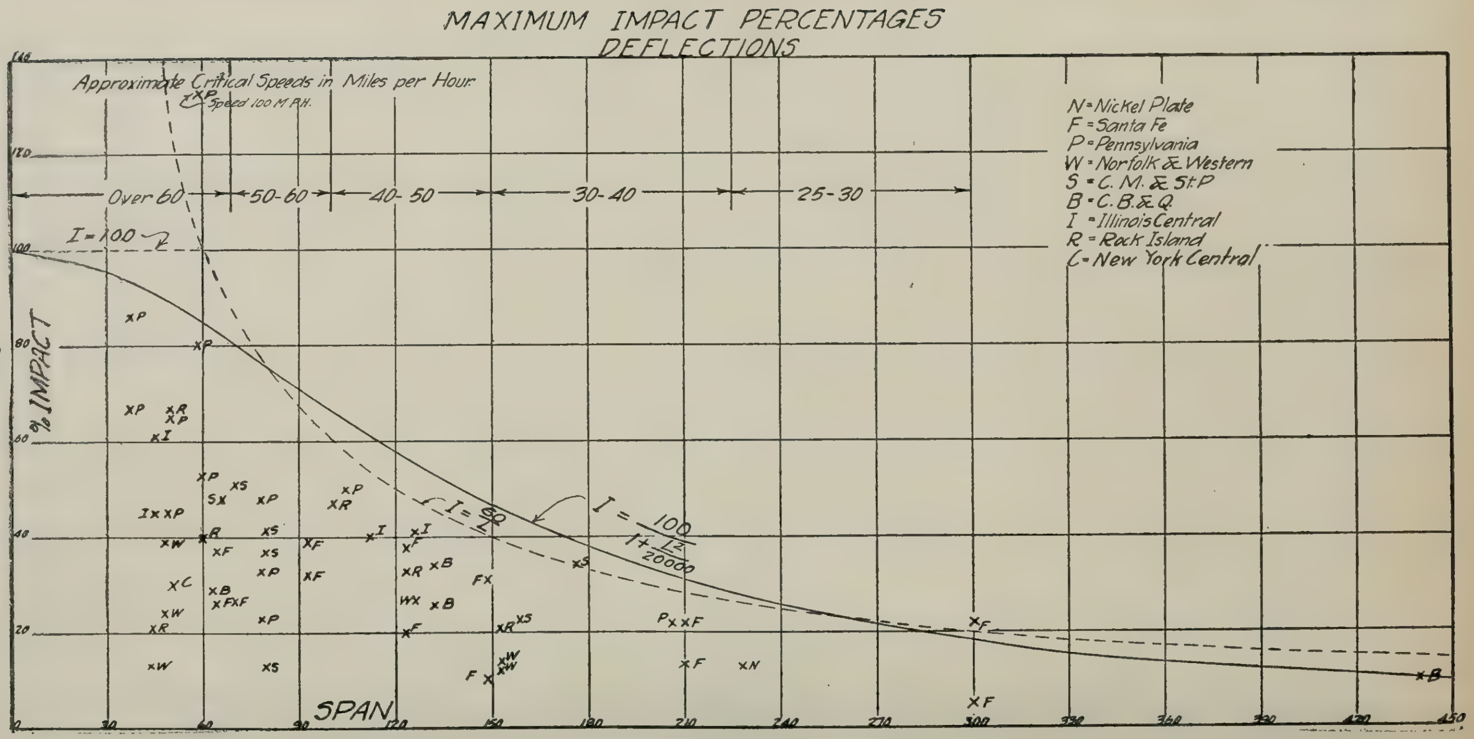
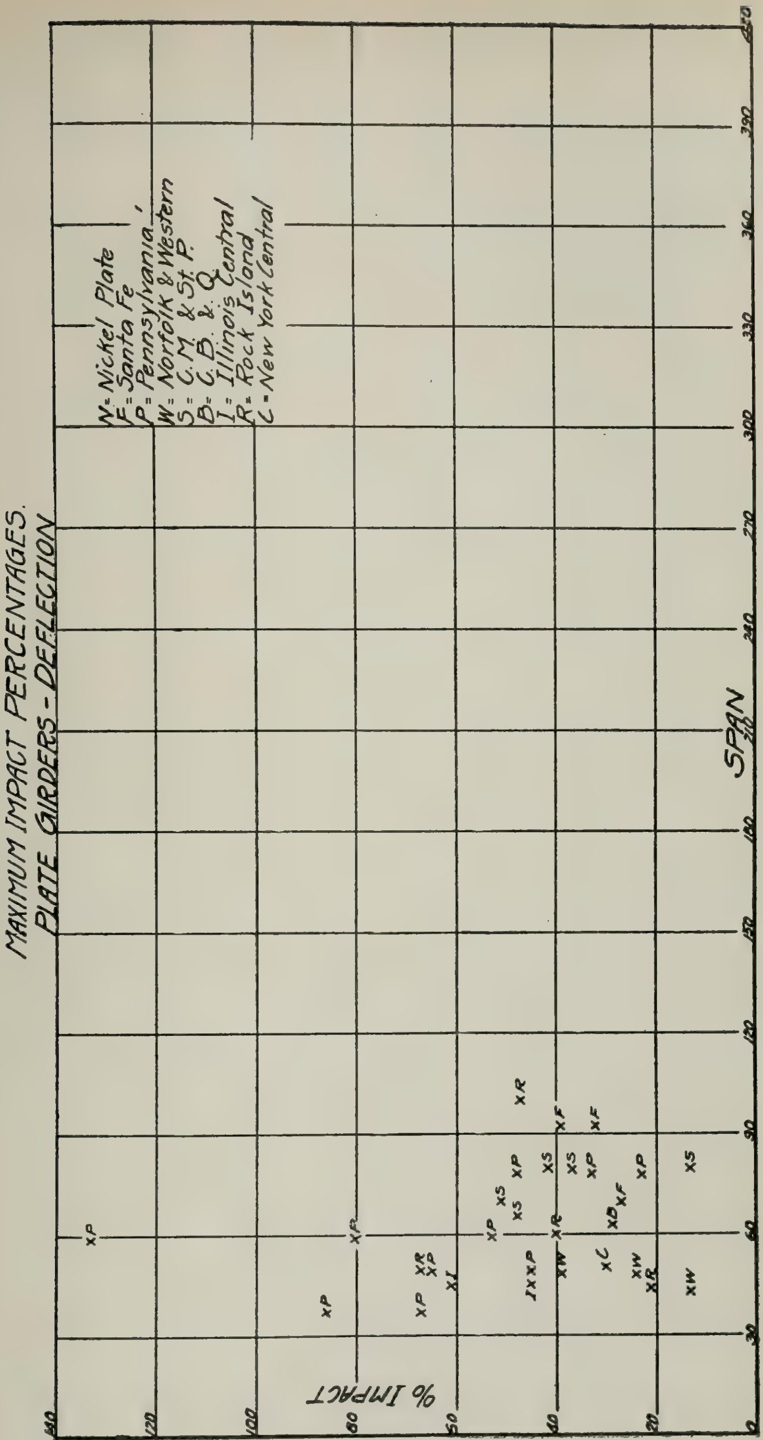
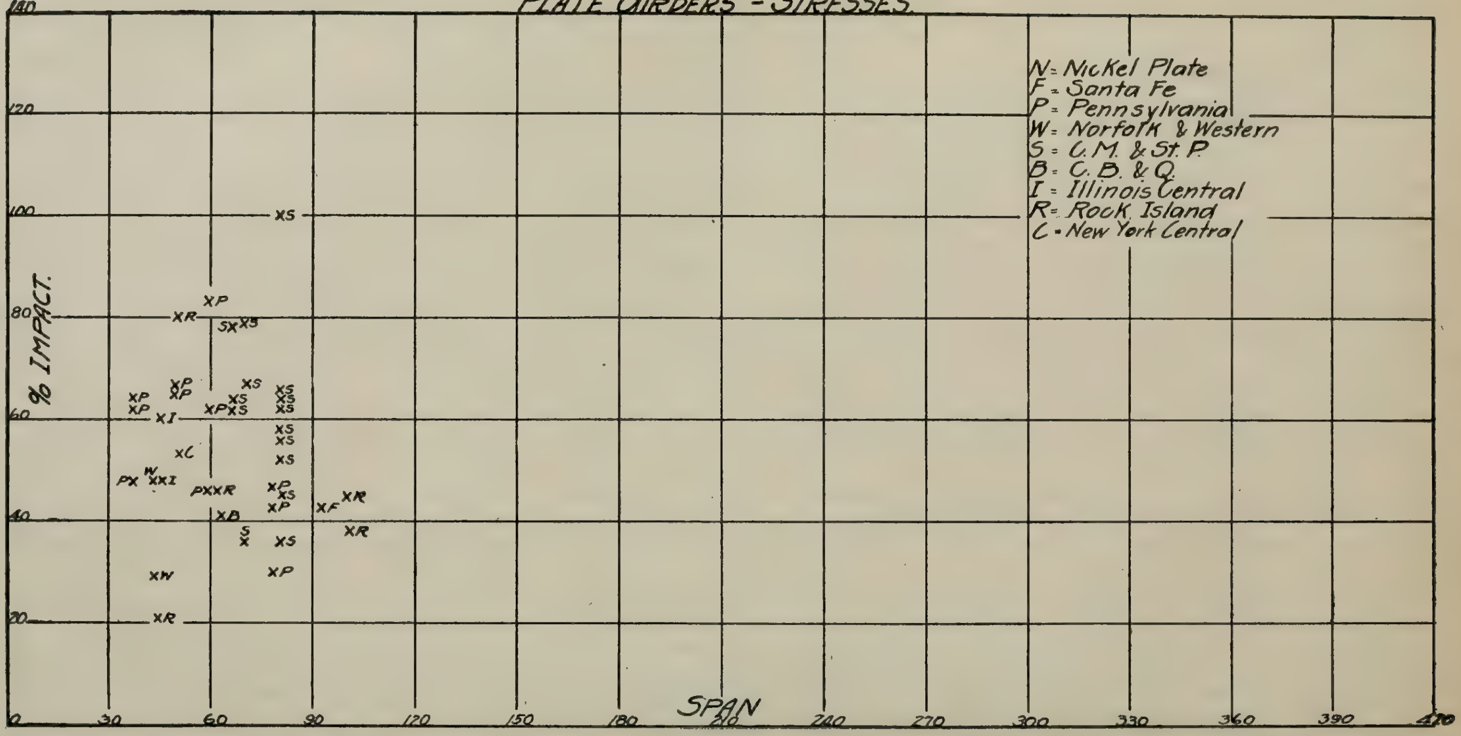

MAXIMUM IMPACT PERCENTAGES
DEFLECTIONS
Approximate Critical Speeds in Miles per Hour.
Speed 100 M.P.H.
Over 60
50-60
40-50
30-40
25-30
I = 100
I = 60/L
I = 100/(1 + L²/20000)
N = Nickel Plate
F = Santa Fe
P = Pennsylvania
W = Norfolk & Western
S = C. M. & St. P
B = C. B. & Q.
I = Illinois Central
R = Rock Island
C = New York Central
% IMPACT
SPAN
0
20
40
60
80
100
120
140
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450

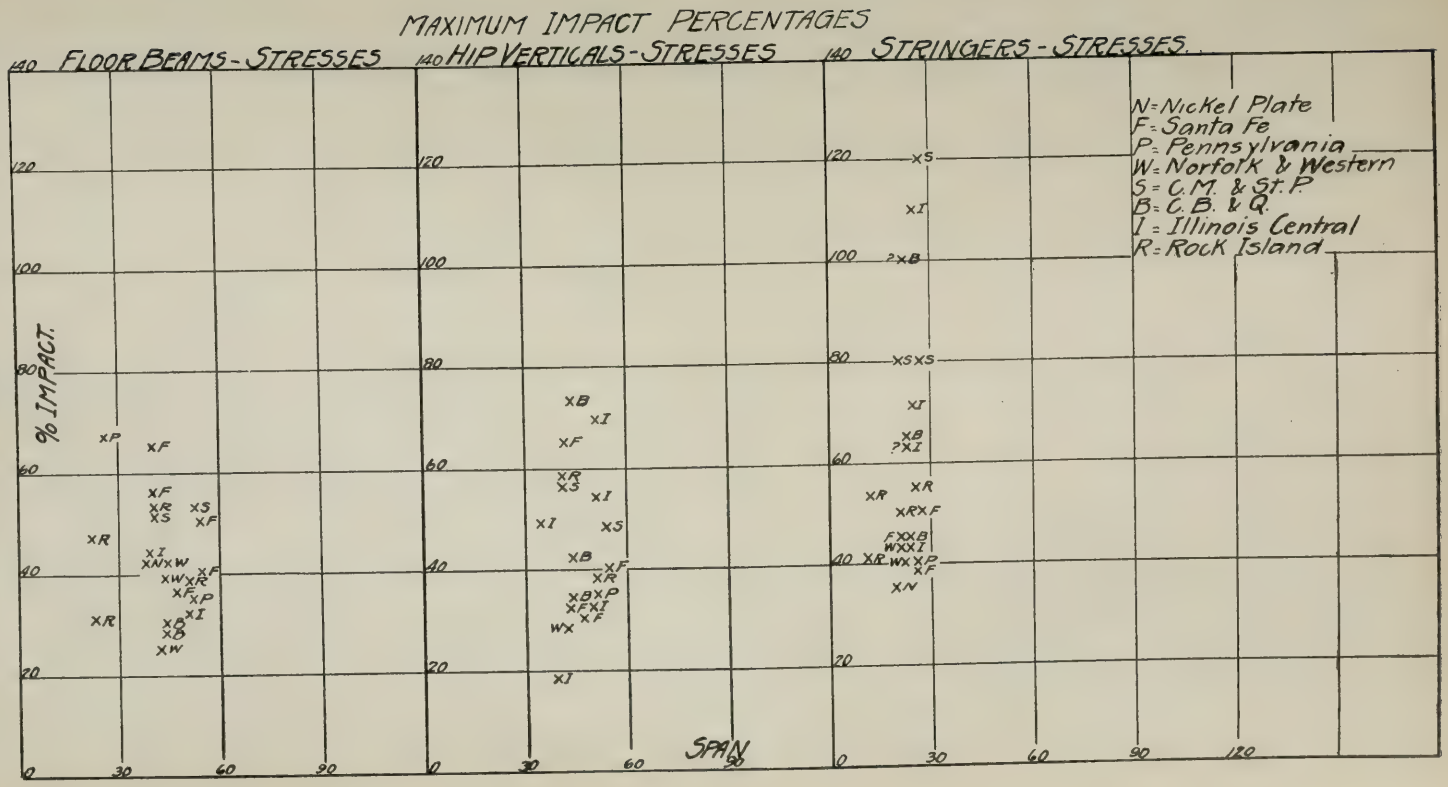
PLATE VI.



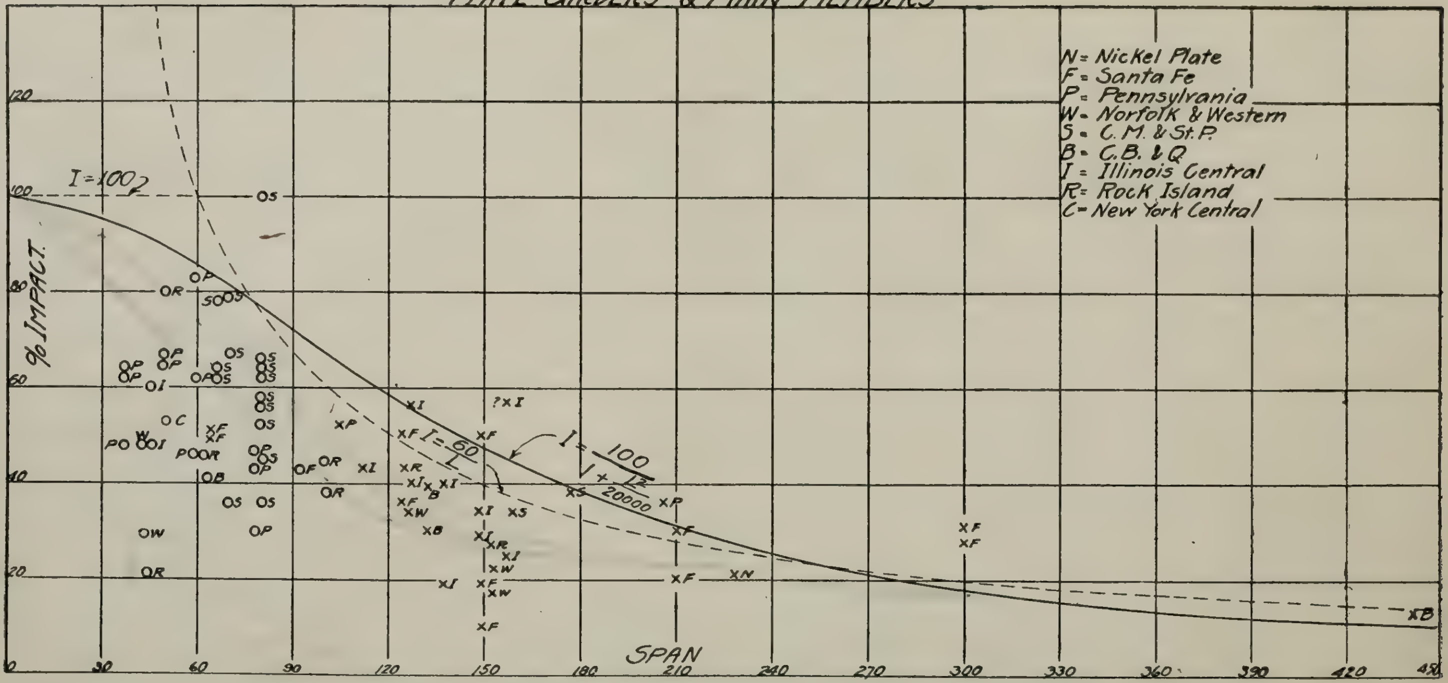
MAXIMUM IMPACT PERCENTAGES.
PLATE GIRDERS - DEFLECTION

MAXIMUM IMPACT PERCENTAGES
PLATE GIRDERS - STRESSES




MAXIMUM IMPACT PERCENTAGES
FLOOR BEAMS - STRESSES
HIP VERTICALS - STRESSES
STRINGERS - STRESSES
% IMPACT.
SPAN
140
120
100
80
60
40
20
0
30
60
90
120
N=Nickel Plate
F=Santa Fe
P=Pennsylvania
W=Norfolk & Western
S=C.M. & St.P.
B=C.B. & Q.
I=Illinois Central
R=Rock Island
XP
XF
XR
XS
XN
XW
XB
XI
?XB
?XI
WX

MAXIMUM IMPACT PERCENTAGES
PLATE GIRDERS & MAIN MEMBERS



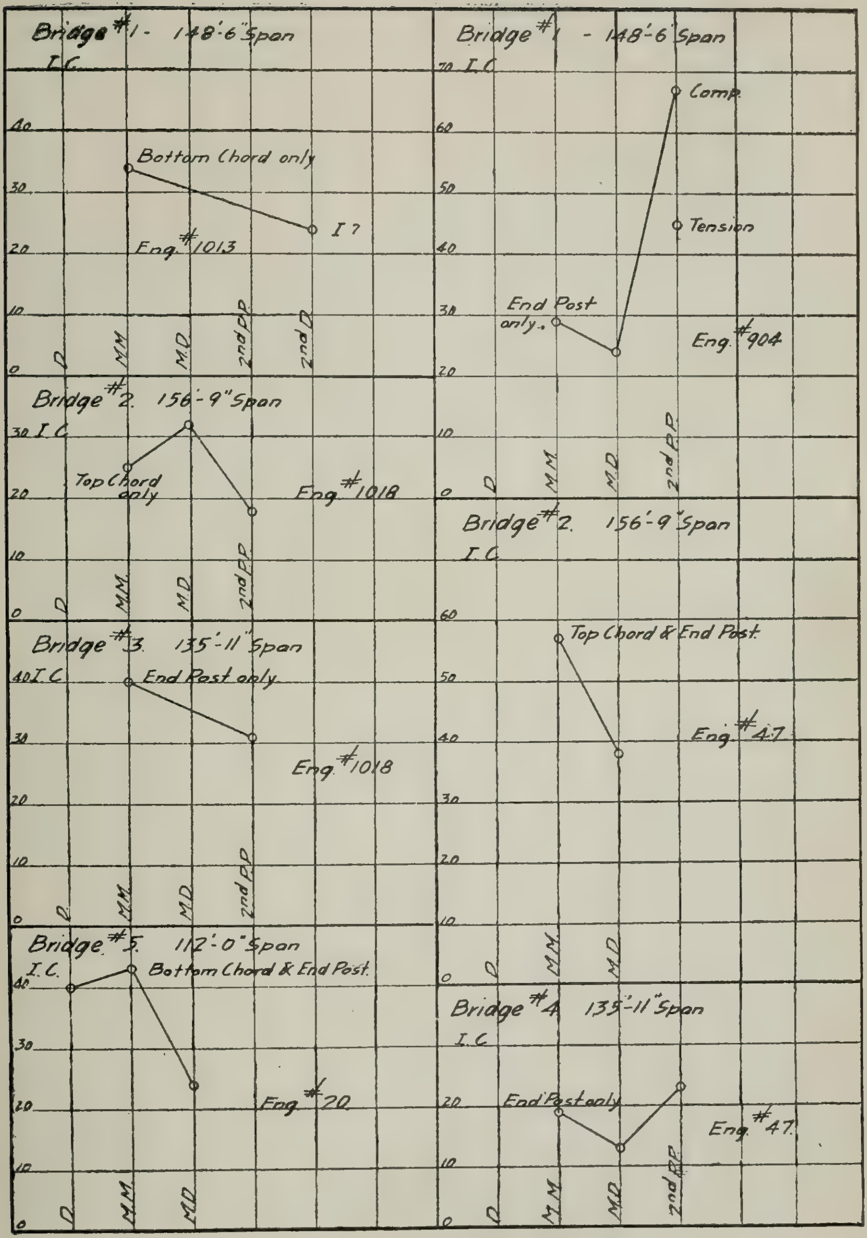
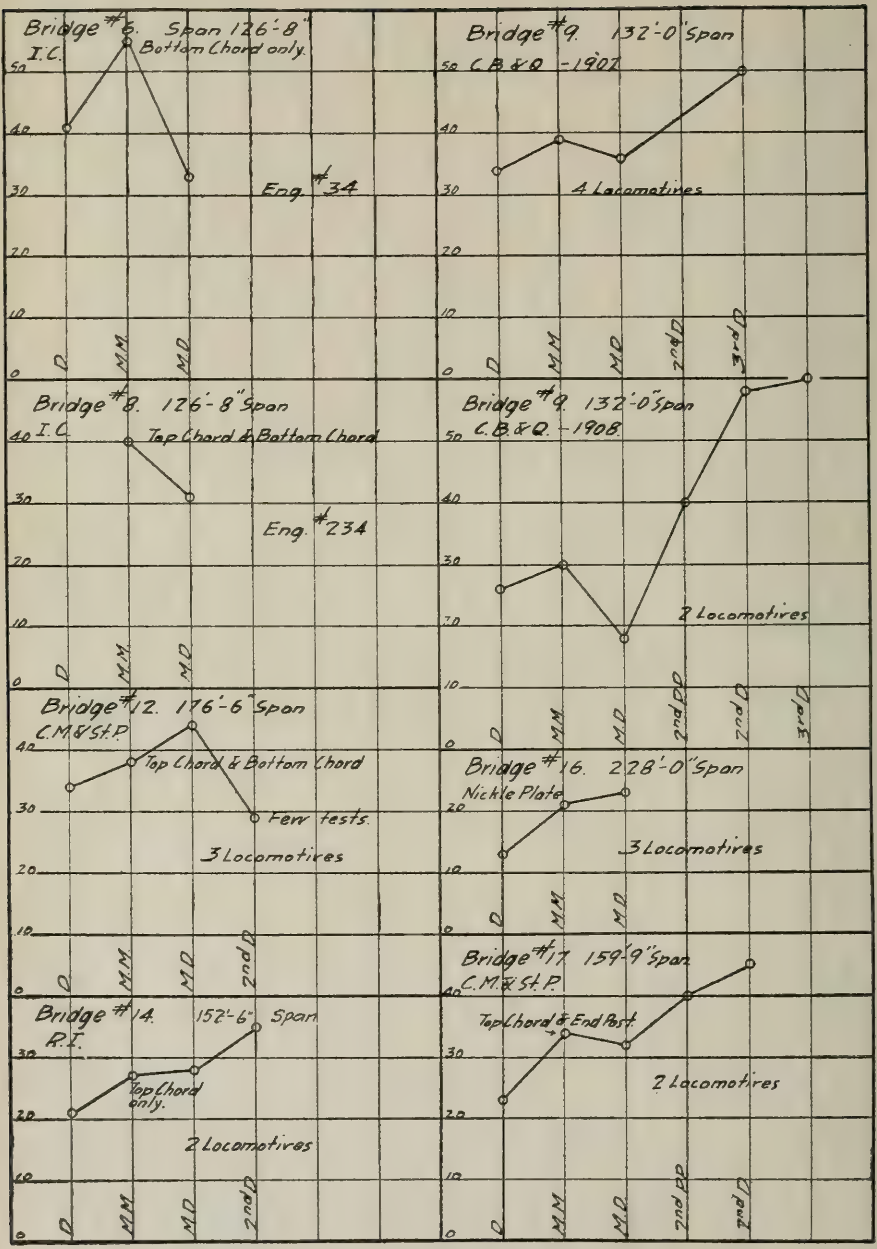

Bridge #1 - 148'-6" Span
I.C.
40
Bottom Chord only
30
I ?
20
Eng. #1013
10
0
D
M.M.
M.D.
2nd P.P.
2nd D.
Bridge #2. 156'-9" Span
30 I.C.
Top Chord only
20
Eng. #1018
10
0
D
M.M.
M.D.
2nd P.P.
Bridge #3. 135'-11" Span
40 I.C.
End Post only.
30
Eng. #1018
20
10
0
D
M.M.
M.D.
2nd P.P.
Bridge #5. 112'-0" Span
I.C.
40
Bottom Chord & End Post.
30
20
Eng. #20
10
0
D
M.M.
M.D.
Bridge #1 - 148'-6" Span
70 I.C.
Comp.
60
50
Tension
40
End Post only.
30
Eng. #904
20
10
0
D
M.M.
M.D.
2nd P.P.
Bridge #2. 156'-9" Span
I.C.
60
Top Chord & End Post.
50
40
Eng. #47
30
20
10
0
D
M.M.
M.D.
Bridge #4 135'-11" Span
I.C.
20
End Post only
Eng. #47
10
0
D
M.M.
M.D.
2nd P.P.

PLATE X—b.


Bridge #5. Span 126'-8"
I.C.
Bottom Chord only.
Eng. #34
Bridge #9. 132'-0" Span
C.B.&Q. -1907
4 Locomotives
Bridge #8. 126'-8" Span
I.C.
Top Chord & Bottom Chord
Eng. #234
Bridge #9. 132'-0" Span
C.B.&Q. -1908
2 Locomotives
Bridge #12. 176'-6" Span
C.M.&St.P.
Top Chord & Bottom Chord
Few tests.
3 Locomotives
Bridge #16. 228'-0" Span
Nickle Plate
3 Locomotives
Bridge #14. 152'-6" Span
R.I.
Top Chord only.
2 Locomotives
Bridge #17 159'-9" Span
C.M.&St.P.
Top Chord & End Post
2 Locomotives
0
10
20
30
40
50
D
M.M.
M.D
2nd D
3rd D
2nd DD

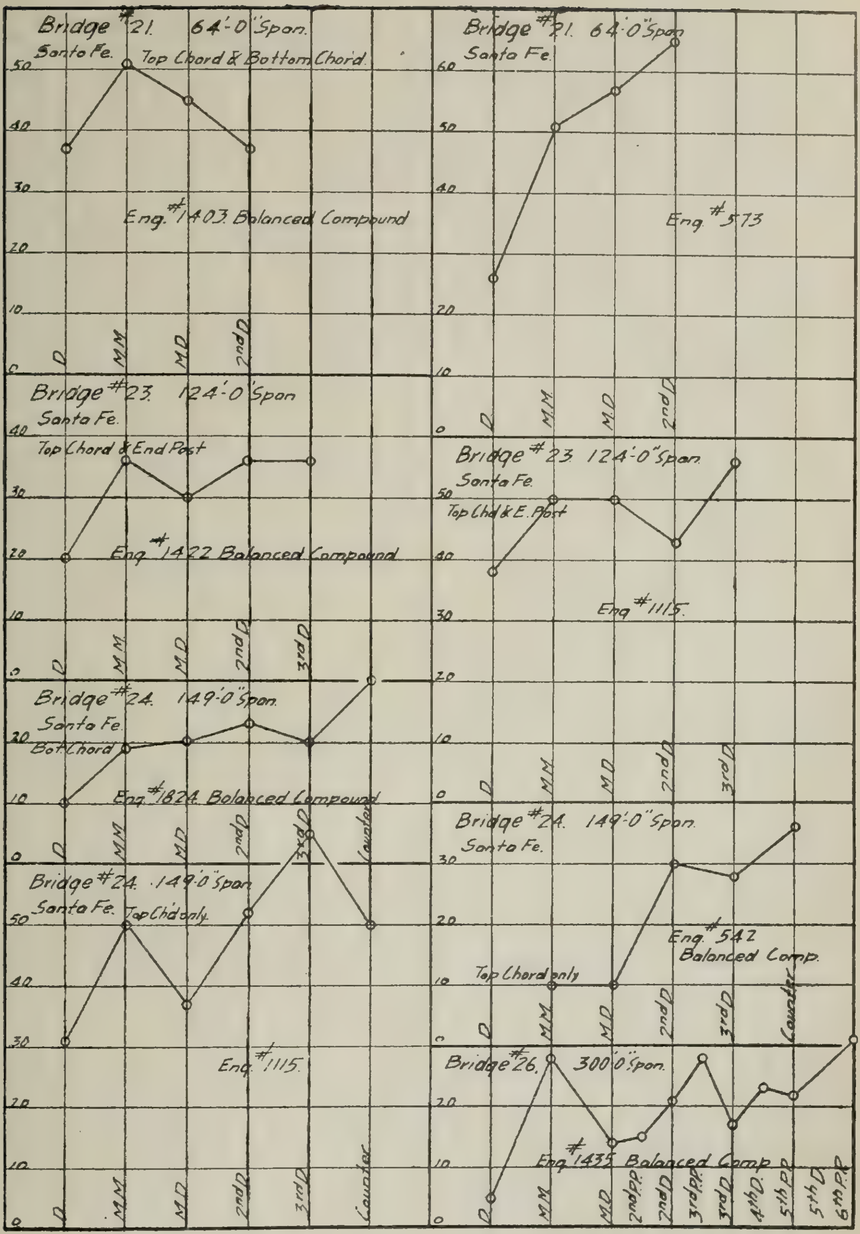
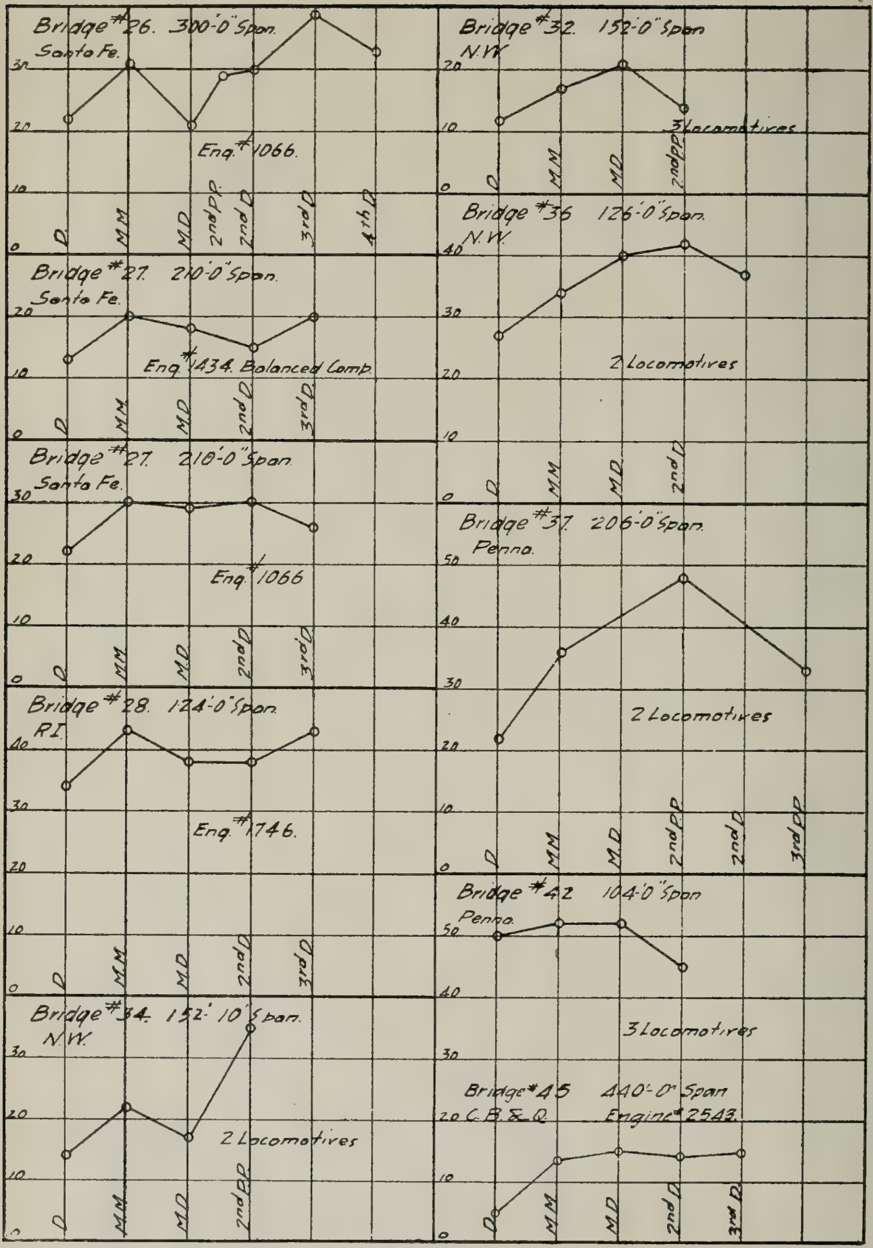

Bridge #21. 64'-0" Span.
Santa Fe.
Top Chord & Bottom Chord.
Eng. #1403 Balanced Compound
Bridge #21. 64'-0" Span
Santa Fe.
Eng. #573
Bridge #23. 124'-0" Span
Santa Fe.
Top Chord & End Post
Eng. #1422 Balanced Compound
Bridge #23. 124'-0" Span.
Santa Fe.
Top Chd & E. Post
Eng. #1115.
Bridge #24. 149'-0" Span.
Santa Fe.
Bot. Chord
Eng. #1824. Balanced Compound
Bridge #24. 149'-0" Span.
Santa Fe.
Top Chord only
Eng. #542
Balanced Comp.
Bridge #24. 149'-0" Span
Santa Fe.
Top Chd only
Eng. #1115.
Bridge #26. 300'0" Span.
Eng. #1435 Balanced Comp.
D
M.M.
M.D.
2nd D
3rd D
Counter
2nd P.P.
3rd P.P.
4th D.
5th P.P.
5th D.
6th P.P.
0
10
20
30
40
50
60

PLATE X—d.


Bridge #26. 300'-0" Span.
Santa Fe.
Eng. #1066.
D
M.M.
M.D.
2nd P.P.
2nd D
3rd D
4th D
Bridge #27. 210'-0" Span.
Santa Fe.
Eng. #1434. Balanced Comp.
D
M.M.
M.D.
2nd D
3rd D
Bridge #27. 210'-0" Span.
Santa Fe.
Eng. #1066
D
M.M.
M.D.
2nd D
3rd D
Bridge #28. 124'-0" Span.
R.I.
Eng. #1746.
D
M.M.
M.D.
2nd D
3rd D
Bridge #34. 152'-10" Span.
N.W.
2 Locomotives
D
M.M.
M.D.
2nd P.P.
Bridge #32. 152'-0" Span
N.W.
3 Locomotives.
D
M.M.
M.D.
2nd P.P.
Bridge #36 126'-0" Span.
N.W.
2 Locomotives
D
M.M.
M.D.
2nd D
Bridge #37. 206'-0" Span.
Penna.
2 Locomotives
D
M.M.
M.D.
2nd P.P.
2nd D
3rd P.P.
Bridge #42 104'-0" Span
Penna.
3 Locomotives
Bridge #45 440'-0" Span
C.B.&Q. Engine #2543.
D
M.M.
M.D.
2nd D
3rd D
0
10
20
30
40
50

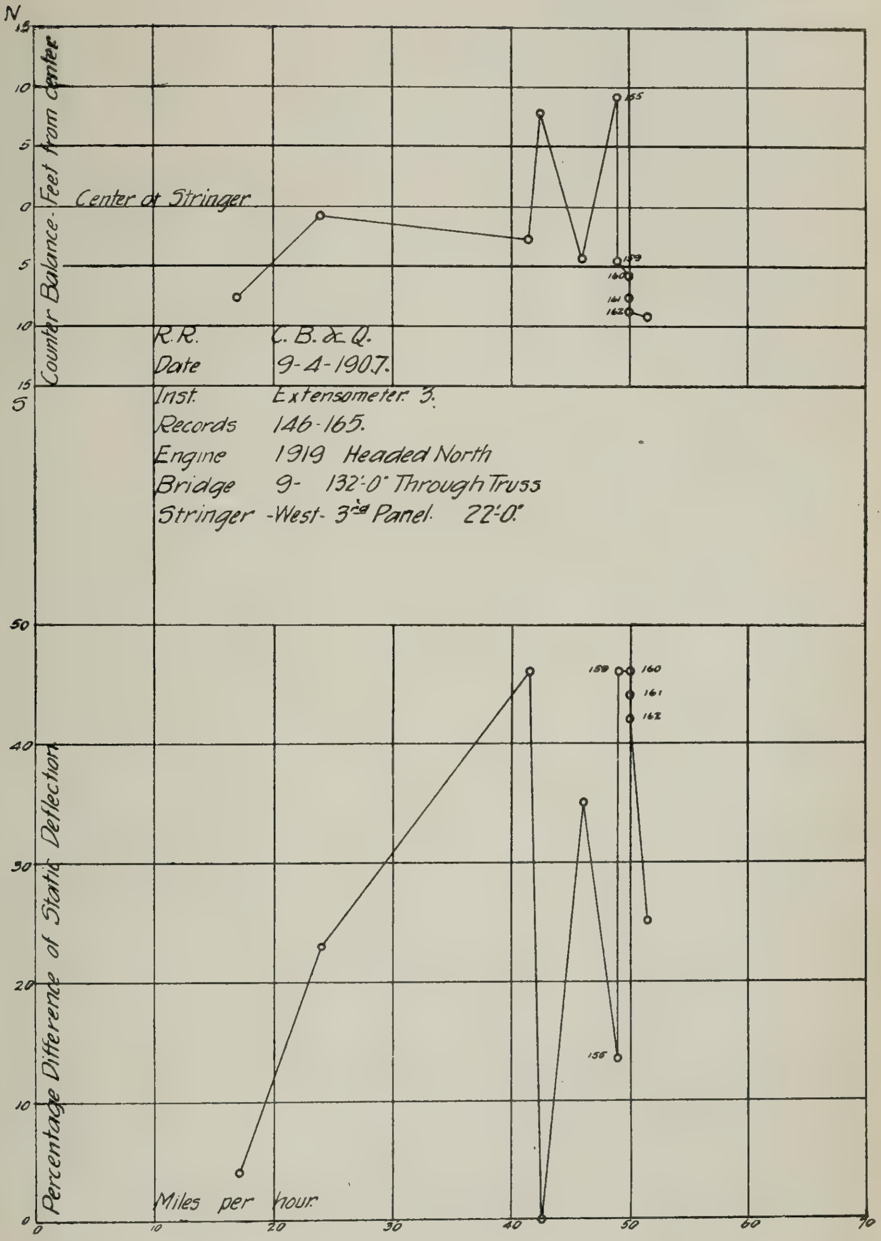
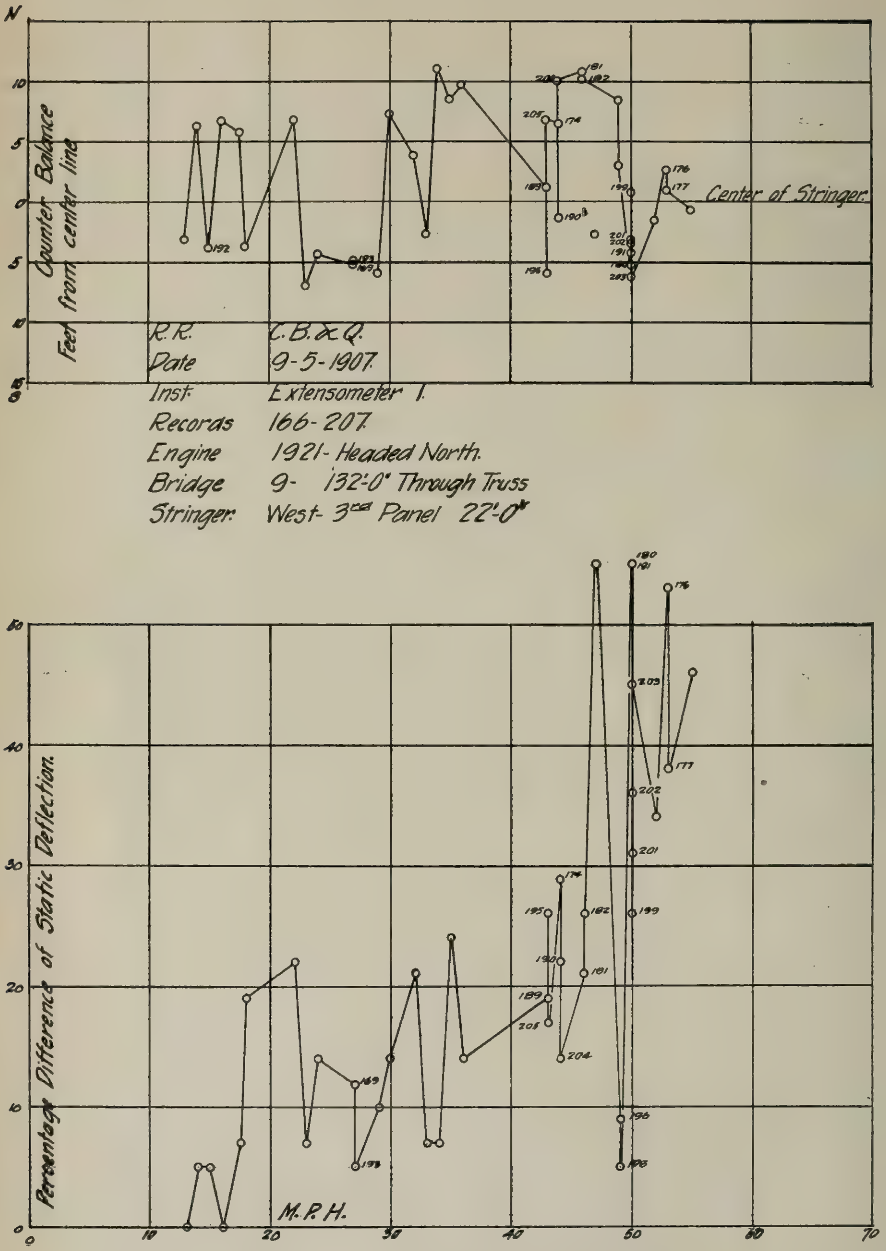
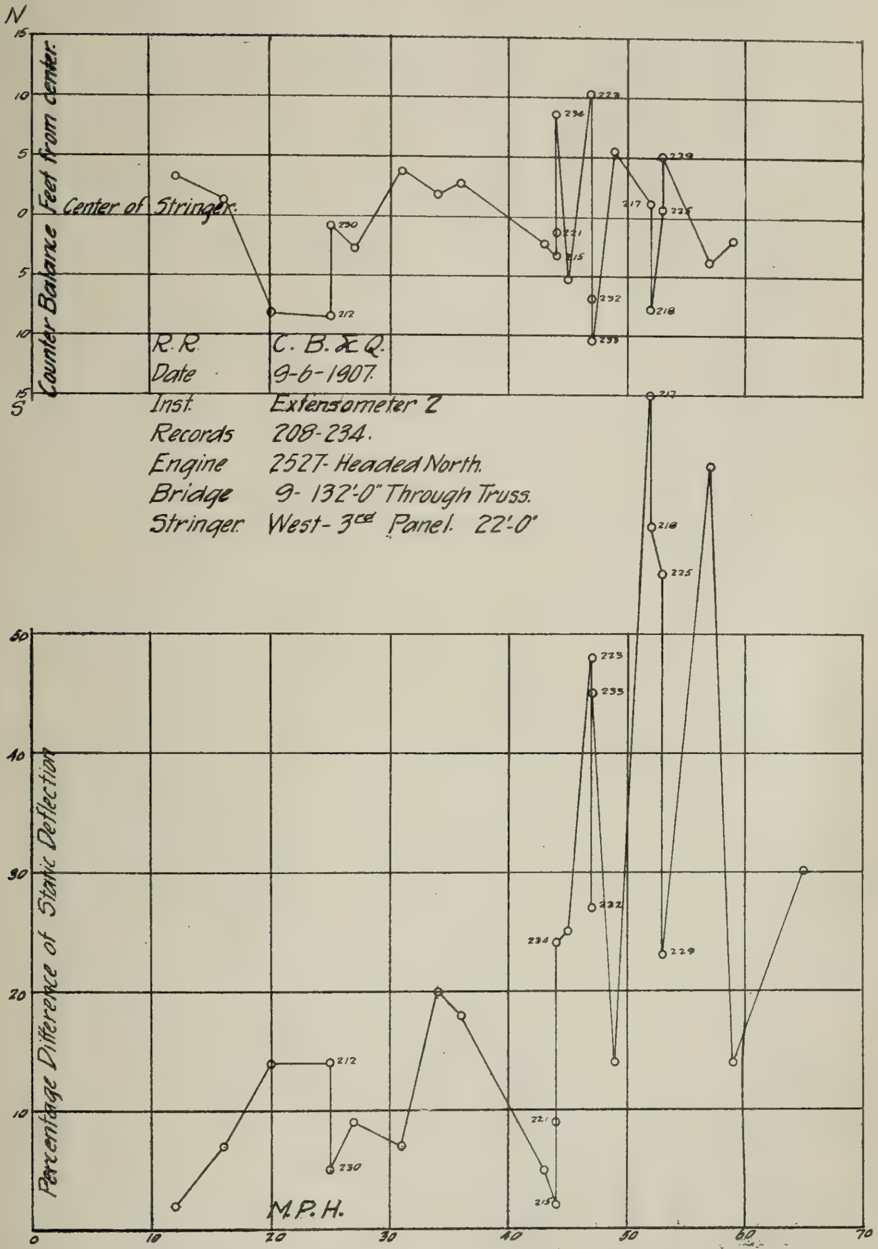

N
Counter Balance - Feet from Center
Center of Stringer
15
10
5
0
5
10
15
S
155
159
160
161
162
R.R. C. B. & Q.
Date 9-4-1907.
Inst. Extensometer 3.
Records 146-165.
Engine 1919 Headed North
Bridge 9- 132'-0" Through Truss
Stringer -West- 3rd Panel. 22'-0"
Percentage Difference of Static Deflection
50
40
30
20
10
0
159
160
161
162
156
Miles per hour
0
10
20
30
40
50
60
70

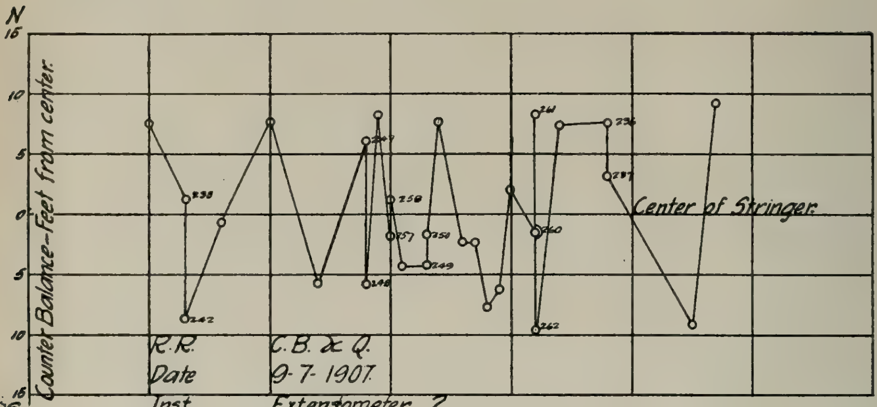
PLATE XI—b.


N
Counter Balance
Feet from center line
10
5
0
5
10
15
Center of Stringer.
R.R. C.B.&Q.
Date 9-5-1907.
Inst. Extensometer 1.
Records 166-207.
Engine 1921- Headed North.
Bridge 9- 132'-0" Through Truss
Stringer. West- 3rd Panel 22'-0"
Percentage Difference of Static Deflection.
50
40
30
20
10
0
M.P.H.
0
10
20
30
40
50
60
70

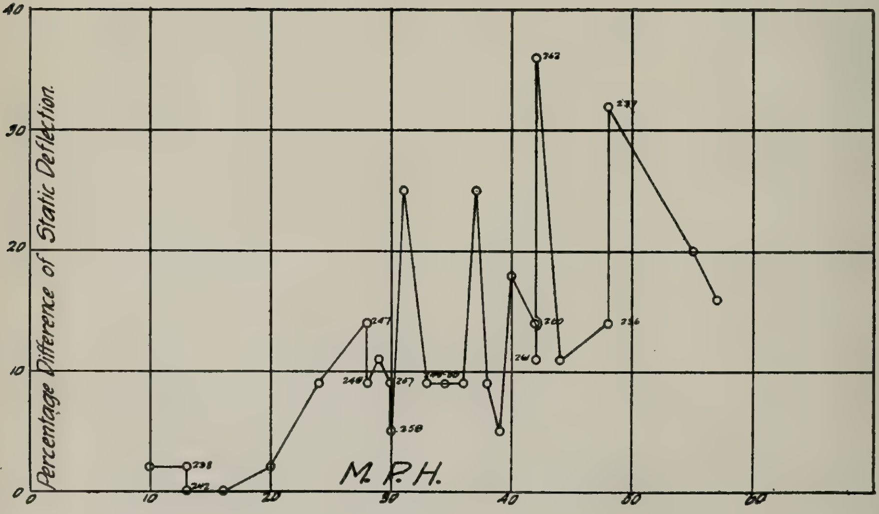


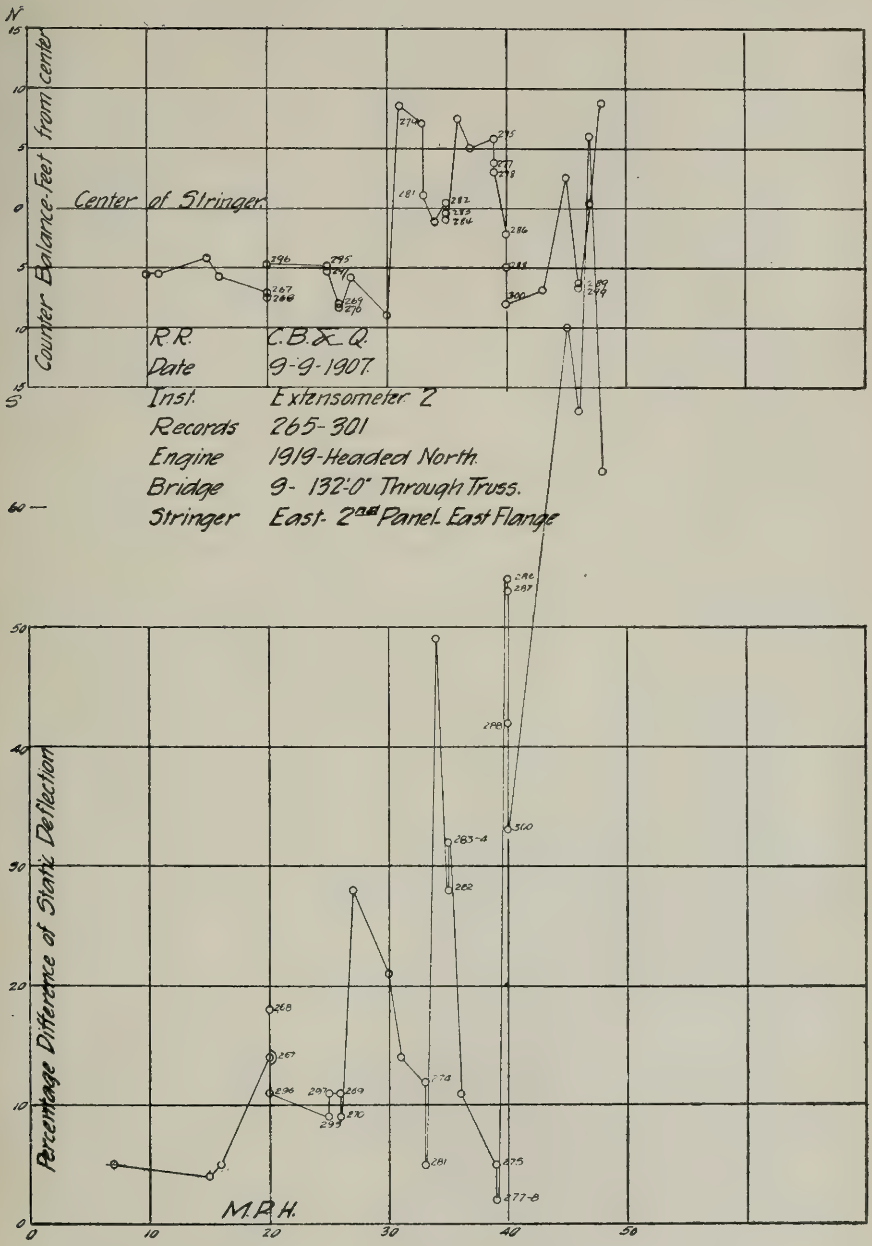
R.R. C. B. & Q.
Date 9-6-1907.
Inst. Extensometer Z
Records 208-234.
Engine 2527- Headed North.
Bridge 9- 132'-0" Through Truss.
Stringer West- 3rd Panel. 22'-0"

PLATE XI—d.



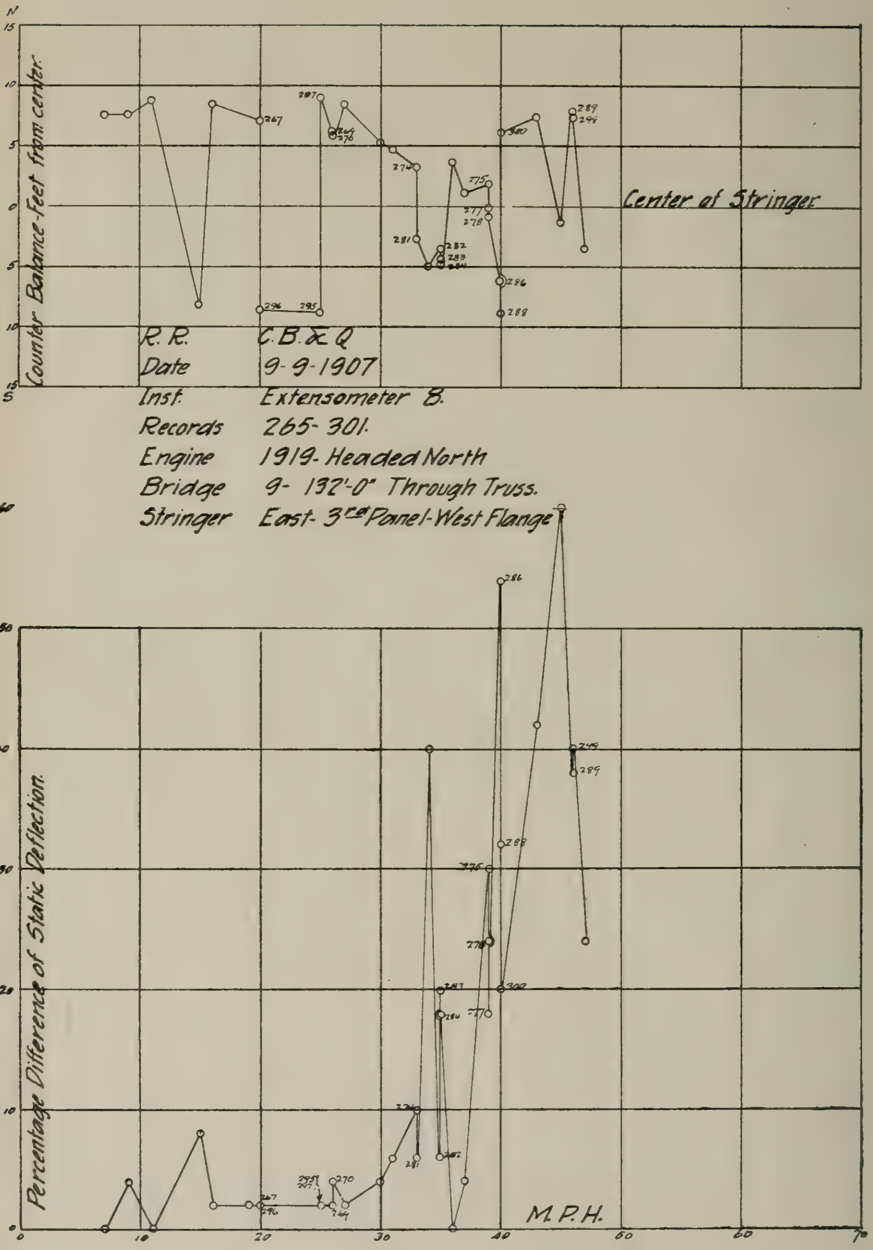
R.R.	C.B. & Q.
Date	9-7-1907.
Inst.	Extensometer Z.
Records	235-264.
Engine	2523 Headed North.
Bridge	9 - 132'-0" Through Truss.
Stringer	West-3rd Panel. 22'-0."

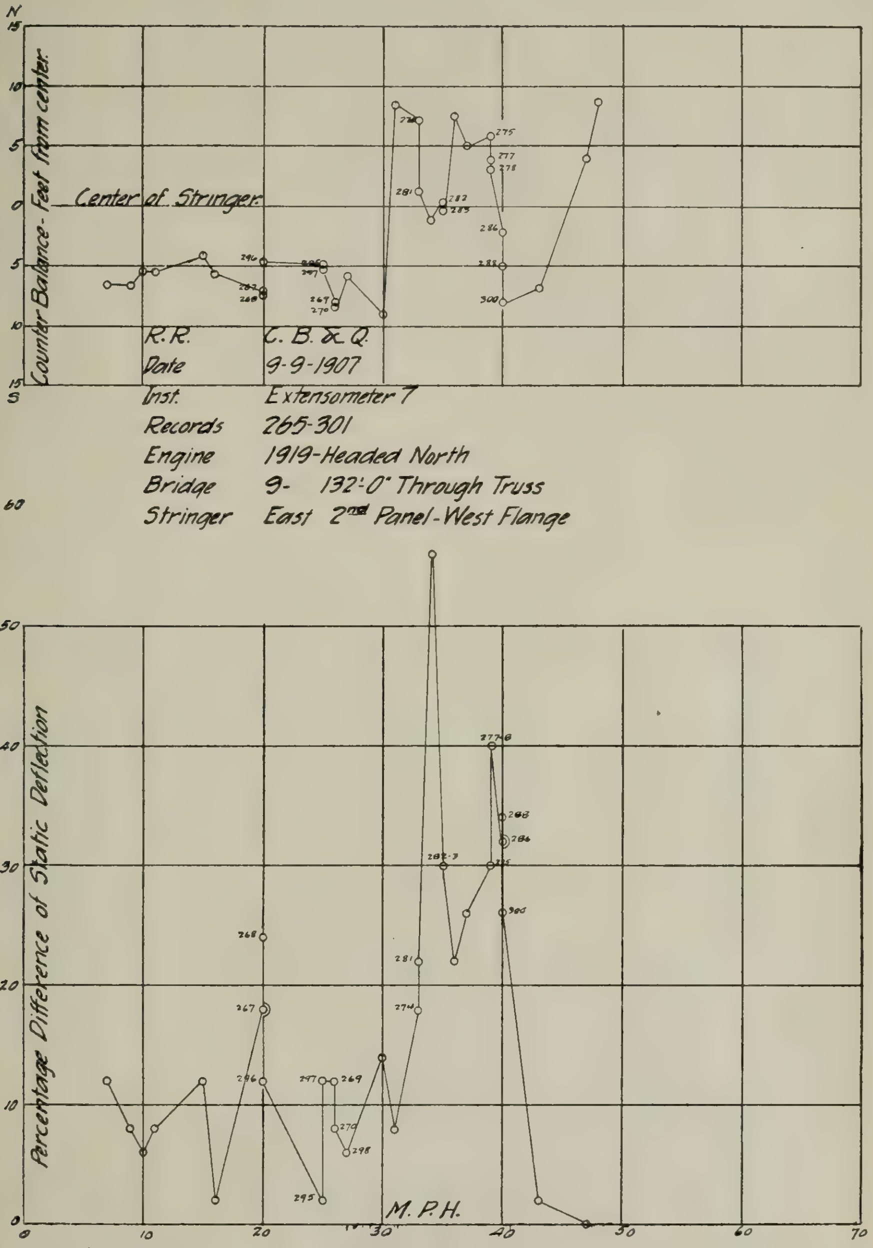




R.R. C.B.&Q.
Date 9-9-1907.
Inst. Extensometer 2
Records 265-301
Engine 1919-Headed North.
Bridge 9- 132'-0" Through Truss.
Stringer East- 2nd Panel. East Flange

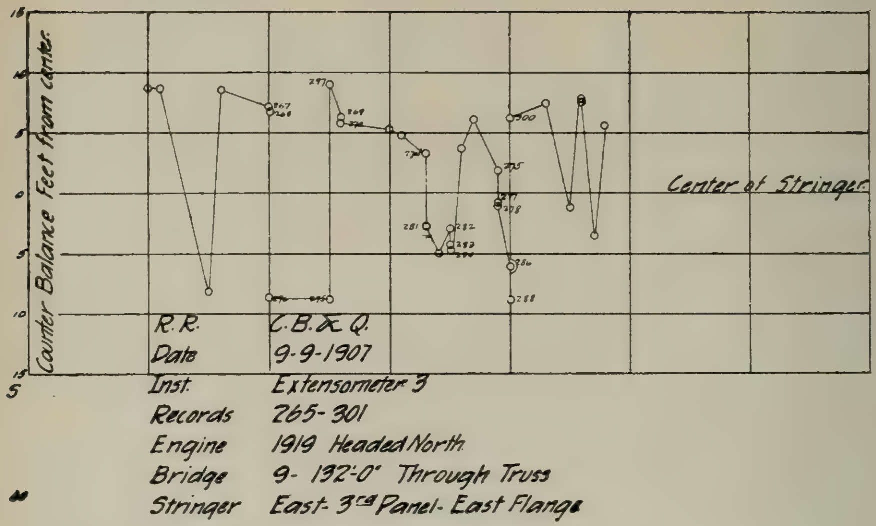
PLATE XI—f.

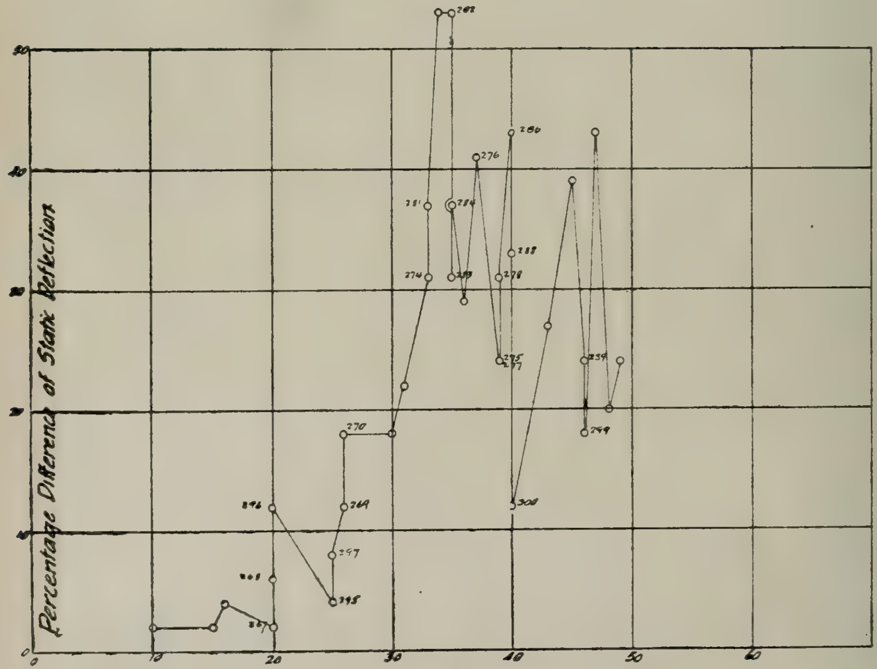

N
15
10
5
0
5
10
15
S
Counter Balance-Feet from center.
Center of Stringer.
R. R. C. B. & Q.
Date 9-9-1907
Inst. Extensometer B.
Records 265-301.
Engine 1919-Headed North
Bridge 9-132'-0" Through Truss.
Stringer East-3rd Panel-West Flange
60
50
40
30
20
10
0
Percentage Difference of Static Deflection.
M.P.H.
0
10
20
30
40
50
60
70
267
296
295
287
269
276
274
281
282
283
284
275
277
278
286
288
300
289
299

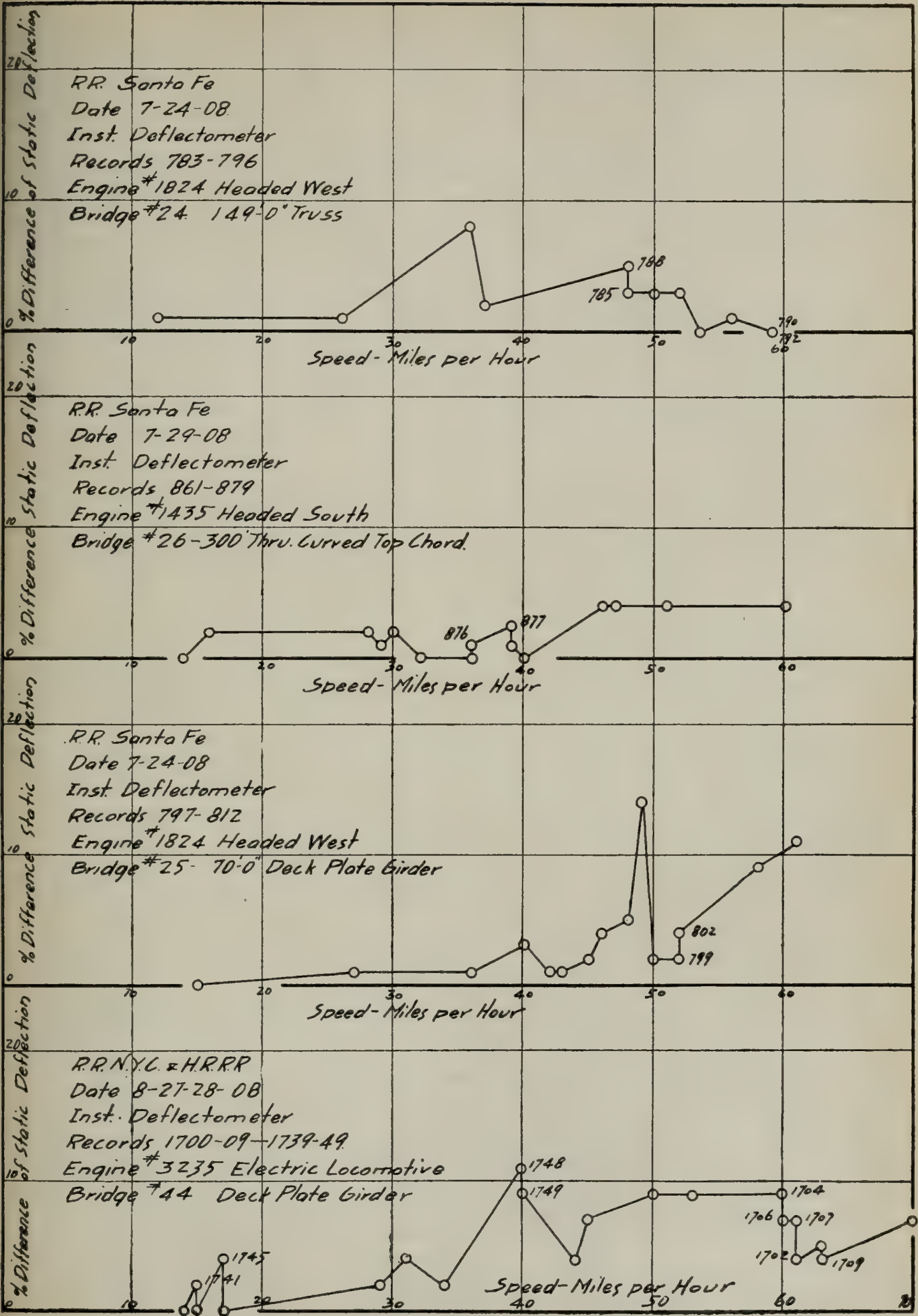


R.R. C. B. & Q.
Date 9-9-1907
Inst. Extensometer 7
Records 265-301
Engine 1919-Headed North
Bridge 9- 132'-0" Through Truss
Stringer East 2nd Panel-West Flange

PLATE XI—h.


Counter Balance Feet from center.
15
10
5
0
5
10
15
Center of Stringer
R.R. C.B.&Q.
Date 9-9-1907
Inst. Extensometer 3
Records 265-301
Engine 1919 Headed North
Bridge 9- 132'-0" Through Truss
Stringer East- 3rd Panel- East Flange
297
267
268
269
270
274
281
282
283
284
275
277
278
286
288
300


Percentage Difference of Static Deflection
50
40
30
20
10
0
0
10
20
30
40
50
60
282
286
276
281
284
288
274
283
278
275
277
299
270
296
269
300
297
298
267


% Difference of Static Deflection
20
10
0
R.R. Santa Fe
Date 7-24-08
Inst. Deflectometer
Records 783-796
Engine #1824 Headed West
Bridge #24. 149'-0" Truss
788
785
790
792
10
20
30
40
50
60
Speed - Miles per Hour
% Difference Static Deflection
20
10
0
R.R. Santa Fe
Date 7-29-08
Inst. Deflectometer
Records 861-879
Engine #1435 Headed South
Bridge #26 - 300' Thru. Curved Top Chord.
876
877
10
20
30
40
50
60
Speed - Miles per Hour
% Difference Static Deflection
20
10
0
R.R. Santa Fe
Date 7-24-08
Inst. Deflectometer
Records 797-812
Engine #1824 Headed West
Bridge #25 - 70'-0" Deck Plate Girder
802
799
10
20
30
40
50
60
Speed - Miles per Hour
% Difference of Static Deflection
20
10
0
R.R. N.Y.C. & H.R.R.R.
Date 8-27-28-08
Inst. Deflectometer
Records 1700-09 — 1739-49
Engine #3235 Electric Locomotive
Bridge #44 Deck Plate Girder
1745
1741
1748
1749
1704
1706
1707
1702
1709
Speed - Miles per Hour
10
20
30
40
50
60
70

SUPPLEMENTARY REPORT ON IMPACT.

(Bulletin 130.)

The report on impact presented last year included all work done up to that time. It was felt by the Sub-Committee that the tests covered fairly well spans of from 75 ft. up to perhaps 300 ft., but that it was very desirable to supplement the work by tests on some very long spans, if such could be arranged. Pursuant to this opinion, the Sub-Committee carried out in September, 1910, some tests on the Baltimore & Ohio bridge at Havre de Grace, Md. Tests were made on a through span and a deck span, each of 517 ft., and a through span of 378 ft. The results of these tests are, briefly, as follows:

378-Ft. Span.

Critical speed 26 to 28 miles per hour.

Impact percentages:

- Deflectometer, 3 per cent. to 9 per cent.
- Lower chord, 5 per cent. to 10 per cent.
- Main diagonal, 7 per cent. to 14 per cent.
- End post, 0 per cent. to 8 per cent.

517-Ft. Through Span.

Critical speed 18 to 22½ miles per hour.

Impact percentages:

- Deflectometer, 2 per cent. to 5 per cent.
- Lower chord, 0 per cent. to 6 per cent.
- End post, 5 per cent. to 10 per cent.
- Main diagonal, 5 per cent. to 10 per cent.
- Ninth diagonal, 0 per cent. to 4 per cent.

517-Ft. Deck Span.

Critical speed 18½ to 21½ miles per hour.

Impact percentages:

- Deflectometer, 3 per cent. to 7 per cent.
- Lower chord, 0 per cent. to 10 per cent.
- End post, 4 per cent. to 8 per cent.

The results here obtained, when combined with the data shown on Plate IX. of the Impact Report, do not appear to modify the conclusions there drawn as to probable maximum impact.

No work has been done on very short spans, but the importance of experiments on such spans is well appreciated and some progress has been made on developing an apparatus which will be better adapted for such work than that heretofore used.

Satisfactory progress has also been made in development of apparatus for the measurement of secondary stresses, and it is expected that such apparatus will be available for use during the coming summer.

Appendix B.

SECONDARY STRESSES.

At the meeting of last year the Sub-Committee was authorized by the Association to proceed with tests on secondary stresses. The Sub-Committee was, however, unable to perfect its apparatus in time to make such tests during the available weeks of the summer vacation. It now recommends that the authorization for such work be extended to include next year. The funds remaining from the contributions for impact tests are ample to cover the cost of the work which can be done during the coming year.

Appendix C.

SPECIFICATIONS FOR THE ERECTION OF RAILROAD BRIDGES.

Work to Be Done.

1. The contractor shall erect and adjust all steel work, ready for use.

Plant.

2. The contractor shall provide all tools, machinery, appliances and outfit necessary for the expeditious handling of the work.

False Work.

*3. The contractor shall submit general working plans sufficient to show the proposed method of erection. When the falsework is to be built by the contractor, he shall submit the design of the temporary structure for the approval of the Engineer. The work shall not proceed until these erection plans have been approved in writing, but such approval shall not relieve the contractor from any responsibility. Falsework material will be provided by the Railroad Company.

The temporary structure for use during erection and for maintaining the traffic shall be properly designed and substantially constructed for the loads which shall come upon it. All bents shall be thoroughly secured against movement, both transversely and longitudinally. The bents shall be well secured against settling, and piles used wherever firm bottom cannot be obtained. Upon completion of the erection the temporary structure shall be removed without unnecessary damage, and neatly piled near the site or loaded on cars, as may be directed.

Falsework placed by the Railroad Company under an old structure or for carrying traffic temporarily over a new opening, may be used by the contractor during erection, provided it is not unnecessarily cut and wasted.

Conduct of Work.

*4. The work shall be prosecuted with sufficient force, plant and equipment to expedite its completion to the utmost extent and in such a manner as to be at all times subordinate to the use of the tracks by the Railroad Company, and so as not to interfere with the work of other contractors or to close or obstruct any thoroughfare by land or water, except under proper authority.

Tracks shall not be cut except when authorized by the Engineer, and trains shall not be subjected to any delay other than a reduction of speed, except when special authority shall have been obtained from the Railroad Company.

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*See amendments, pp. 306, 307.

The contractor shall protect traffic and his work by flagmen, furnished by the Railroad Company at the expense of the contractor, and shall provide competent watchmen to guard the work and material against injury.

Engine Service.

5. When worktrain or engine service is furnished the contractor free of charge, such free service shall consist only in unloading materials and in transferring the same from a convenient siding to the bridge site. When such service is desired, the contractor shall give the proper railroad officials at least 24 hours' advance notice, and the Railroad Company will furnish the service as promptly as possible, consistent with railroad operations.

When derrick cars are used on main tracks, their movements will be in charge of a train crew, and the expense of this crew and any engine service other than as noted above shall be charged to the contractor.

Transportation.

6. When transportation of equipment, materials and men is furnished free over the Railroad Company's line, it shall be subject to such conditions as may be stated in the contract.

Masonry.

7. The Railroad Company will finish all masonry to correct lines, and elevations, and unless otherwise stated in the contract, will make all changes in old masonry without unnecessarily impeding the operations of the contractor. The Railroad Company's engineers will establish lines and elevations, but the contractor will compare the elevations, distances, etc., shown on plans with the masonry as actually constructed so far as practicable, before he assembles the steel. In case of discrepancy, he shall immediately notify the Engineer.

Handling and Storing Materials.

8. Cars containing materials or plant shall be promptly unloaded upon delivery, and the contractor shall be liable for demurrage charges. Materials shall be placed on skids above the ground, laid so as not to hold water and stored and handled in such a manner as not to be injured or to interfere with railroad operations. The expense of repairing or replacing material damaged by rough handling shall be charged to the contractor. The contractor, while unloading and storing material, shall compare each piece with the shipping list and promptly report any shortage or injury discovered.

Maintenance of Traffic.

*9. When traffic is to be maintained, it will be carried on in such a manner as to interfere as little as practicable with the work of the contractor.

Changes required during erection shall be at all times under the direct control and supervision of the Railroad Company. Any changes desired to be made by the Railroad Company for insuring greater safety to traffic shall be made by its own forces, and no claim on the part of the contractor for delay or damage on account of such changes will be allowed.

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*See amendments, page 307.

Removal of Old Structure.

10. Metal work in the old structure shall be dismantled without unnecessary damage, and loaded on cars or neatly piled at a site immediately adjacent to the tracks, and at a convenient grade for future handling, as may be directed. When the structure is to be used elsewhere all parts will be matchmarked by the Railroad Company; when the old bridge is composed of several spans the parts of each shall be kept separate.

Steel Work.

*11. Steel work shall be handled without damage or abuse. Threads of all pins shall be protected by pilot and driving nuts while being driven in place.

Light drifting will be permitted in order to draw the parts together; but drifting for the purpose of matching unfair holes shall not be permitted. Unfair holes shall be reamed or drilled.

Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

All splices and field connections shall be securely bolted prior to riveting. When the parts are required to carry traffic, important connections. such as tension splices and attachments of stringers and floor beams, shall have at least fifty (50) per cent. of the holes filled with bolts, and twenty-five (25) per cent. with drift pins; or else, seventy-five (75) per cent. filled with bolts. When not carrying traffic, at least thirty-three and one-third (33⅓) per cent. of the holes shall have bolts.

Rivets in splices of compression members shall not be driven until the members shall have been subjected to the full dead load stresses. Rivets shall be driven tight. No re-cupping or calking will be permitted. The heads shall be full and uniform in size, free from fins, concentric and in full contact with the metal. Heads shall be painted immediately after acceptance.

Rivets shall be uniformly and thoroughly heated and no burnt rivets shall be driven. All loose rivets shall be promptly cut out and re-driven. In removing rivets the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out.

Misfits.

12. Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, and a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Engineer, and the work of correction done in the presence of the Engineer, who shall check the time expended. Minor misfits and a reasonable amount of reaming shall be considered as a legitimate part of the erection, but misfits and badly matched holes, which require drilling or cutting apart, shall be chargeable to the manufacturers.

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*See amendments, page 307.

Anchor Bolts.

13. Holes for all anchor bolts, except where bolts are built up with the masonry, shall be drilled by the contractor after the metal is in place, and shall be set in Portland cement grout.

Bed Plates.

14. Bed plates resting on masonry shall be set level and have a full, even bearing over their entire surface; this shall be attained either by the use of Portland cement grout or mortar, or by tightly ramming in rust cement under the bed plates after blocking them accurately in position.

Decks.

*15. The Railroad Company will place the permanent deck.

Painting.

*16. The paint shall be furnished by the contractor, and shall be of such color, quality and manufacture as may be specified.

Surfaces inaccessible after erection, such as bottoms of base plates, tops of stringers, etc., shall receive two coats of paint before assembling in place. After erection the entire structure shall receive two coats of paint, allowing enough time between coats for the first coat to dry before applying the second. No paint shall be applied in wet or freezing weather, nor when the surface of the metal is damp. Painting shall be done in a good and workmanlike manner, subject to strict inspection during progress and after completion, and in accordance with special instructions which will be given by the Engineer. All metal shall be thoroughly cleaned of dirt, rust, loose scale, etc., before the paint is applied.

Clearing the Site.

17. The contractor, after completion of the work of erection, shall remove all old material and debris and place the premises in a neat condition.

Superintendence and Workmen.

*18. During the entire progress of the work the contractor shall have a competent superintendent in personal charge and shall employ skilled and competent workmen. Instructions given by the Engineer to the superintendent shall be carried out the same as if given to the contractor. If any of the contractor's employes, by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the Engineer, be discharged from the work, nor thereafter be employed upon it without the Engineer's consent.

Inspection.

19. The work of erection shall at all times be subject to the inspection and acceptance of the Engineer.

Responsibility.

*20. The contractor shall assume all responsibility for loss or damage to his own work, materials or plant, due to any cause whatsoever; also, for all loss or damage to the Railroad Company's materials or property, and to other property adjacent to the railroad, due to causes within his reasonable control.

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*See amendments, page 307.

He shall assume all responsibility for injury to the workmen or the public, or to any individual; and in case of accident or suit he shall defend the suit in person and relieve the Railroad Company from all costs and expenses, and pay any judgments that may be recovered thereon.

He shall comply with the local and government laws and ordinances affecting the manner of doing work; shall take out all necessary permits and comply with their requirements, and shall take such precautions as may be necessary to protect life and property.

Insurance.

21. The contractor shall carry such liability insurance as is necessary to protect himself and the Railroad Company against loss or damage caused by injuries to his men, and shall furnish the Railroad Company a bond in form and of a surety acceptable to the Railroad Company, providing for the faithful performance of the work and all matters pertaining thereto, in such sum as shall be specified in the contract.

Engineer.

†22. The term "Engineer," as used herein, shall be understood to mean the Chief Engineer of the Railroad Company or his properly accredited representative.

AMENDMENTS.

Amend the first paragraph of clause 3 of the "Specifications for the Erection of Railroad Bridges" to read as follows:

"3. False-Work. The contractor shall submit general working plans sufficient to show the proposed method of erection. False-work will be built by *............ When the false-work is to be built by the contractor, he shall submit the design of the temporary structure for the approval of the engineer. The work shall not proceed until these erection plans have been approved in writing, but such approval shall not relieve the contractor from any responsibility. False-work material will be provided by the *..........."

Amend the third paragraph of clause 3 to read as follows:

"False-work placed by the Railroad Company under an old structure or for carrying traffic temporarily over a new opening, may be used, as far as practicable, by the contractor during erection, provided it is not unnecessarily cut and wasted."

Amend the second and third paragraphs of clause 4 to read as follows:

"Tracks shall not be cut, nor shall trains be subjected to any delay other than reduction of speed, except when authorized by the engineer."

"The contractor shall protect traffic and his work by flagmen, furnished by the railroad company at the expense of the contractor, and he shall provide competent watchmen to guard the work and material against injury."

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*Insert "Railroad Company" or "Contractor," as the case may be.

†See amendments, page 307.

Amend the second paragraph of clause 9 to read as follows:

"Changes required during erection shall be at all times under the direct control and supervision of the railroad company. No claim on the part of the contractor for delay or damage on account of such changes will be allowed."

Amend the first paragraph of clause 11 to read as follows:

"11. Steel Work. Material shall be handled without damage. Threads of all pins shall be protected by pilot and driving nuts while being driven in place."

Amend clause 15 to read as follows:

"15. Decks. The *.............. will place and frame the permanent deck."

Amend the first paragraph of clause 16 to read as follows:

"16. Painting. The paint will be furnished by *.............., and shall be of such color, quality and manufacture as may be specified."

Amend clause 18 to read as follows:

"18. Superintendence and Workmen. During the entire progress of the work the contractor shall have a competent superintendent in personal charge and shall employ only skilled and competent workmen. Instructions given by the engineer to the superintendent shall be carried out the same as if given to the contractor. If any of the contractor's employes, by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the engineer, be discharged from the work, nor thereafter be employed upon it without the engineer's consent."

Amend the second paragraph of clause 20 to read as follows:

"He shall assume all responsibility for injury to the workmen and the public, or to any individual; and in case of accident or suit he shall defend the suit in person and relieve the railroad company from all costs and expenses, and pay any judgments that may be recovered thereon."

Amend clause 22 to read as follows:

"22. Engineer. The term 'Engineer,' as used herein, shall be understood to mean the Chief Engineer of the Railroad Company or his accredited representative."

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*Insert "Railroad Company" or "Contractor," as the case may be.

Appendix D.

ON THE GREATEST BENDING MOMENT PRODUCED BY COPPER'S E-40 LOADING.

(Bulletin 128.)

By W. H. Schuerman, Professor of Civil Engineering, Vanderbilt University.

As usually stated in textbooks, the condition for maximum moment at any point of a span is that the average load on either side of the point must equal the average load on the span. This is a *necessary* condition for a maximum moment, but it is not a *sufficient* condition. In fact, it is just as necessary a condition for a minimum moment.*

With concentrated loads applied at points of the span and with a load at either end of the span or at the point where the B. M. (bending moment) is to be found or at any two or all three of these points, the condition mentioned above cannot in general be exactly satisfied because either or all of the average loads will be increased or diminished by a finite quantity when the load moves an infinitesimal distance to right or left. Actually, of course, the loads are distributed over small but measurable lengths of rail, and if this be taken into account, the condition can be exactly met. However, in what follows it will, as usual, be assumed that the loads are concentrated at points.

Let AB be the span of length *l*, A being the left end and B the right end; C is the center of the span. Let P be any point in the span at the distance x from A at which we are considering the B. M. Let the loads be designated by W's, the different loads being distinguished by subscripts and let W_A, W_B, and W_P be the first loads to the left of the points A, B and P respectively, except when there is a load at any one of the points when the load is designated by the corresponding subscript. Let $\Sigma^{'}_{,}W$ be the sum of any number of consecutive loads, the loads in the summation being indicated by the limits attached to the summation sign; thus the sum of all the loads on the span would be $\sum_{a+1}^{b} W$. The conditions for maximum and minimum B. M.'s at P will be stated without proof.

(1) No maximum B. M. can occur unless there is a load at P.

(2) No minimum B. M. can occur unless there is a load at A or B or at both.

For the statement of additional necessary conditions, all possible cases of loading will be divided into the following:

I. When there is no load at either A or B.

II. When there is a load at either A or B.

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*See "Modern Framed Structures," Johnson, Bryan & Turneaure, 8th Ed., p. 83; 9th Ed., p. 198.

III. When there is a load at both A and B.

Each of these will be subdivided into two cases, one when there is a load at P and one when there is no load at P.

I. If there is no load at P, neither a maximum nor a minimum B. M. is possible. If there is a load at P, a minimum is impossible, but a maximum will occur if $\frac{x}{l}\sum_{a+1}^{b} W$ be less than $\sum_{a+1}^{p} W$ and greater than $\sum_{a+1}^{p-1} W$.

II. If there be no load at P, a maximum is impossible, but a minimum will occur if $\frac{l}{x}\sum_{a+1}^{p} W$ be less than $\sum_{a+1}^{b} W$ and greater than $\sum_{a+1}^{b-1} W$, the load being assumed at B.

If there be a load at P, a maximum will occur if $\sum_{a+1}^{p} W$ be greater than $\frac{x}{l}\sum_{a+1}^{b} W$ and if $\sum_{a+1}^{p-1} W$ be less than $\frac{x}{l}\sum_{a}^{b-1} W$; a minimum will occur if $\sum_{a+1}^{p-1} W$ be greater than $\frac{x}{l}\sum_{a+1}^{b-1} W$ and $\sum_{a+1}^{p} W$ be less than $\frac{x}{l}\sum_{a+1}^{b} W$, the load being assumed at B.

With the concentrated load at A instead of B, the conditions are exactly similar, the two parts into which P divides the span being simply interchanged.

III. If there be no load at P, no maximum is possible and a minimum will occur if $\sum_{a}^{p} W$ be greater than $\frac{x}{l}\sum_{a}^{b-1} W$ and $\sum_{a+1}^{p} W$ be less than $\frac{x}{l}\sum_{a+1}^{b} W$.

If there be a load at P, a maximum will occur if $\sum_{a+1}^{p} W$ be greater than $\frac{x}{l}\sum_{a+1}^{b} W$ and $\sum_{a}^{p-1} W$ be less than $\frac{x}{l}\sum_{a}^{b-1} W$; and a minimum will occur if $\sum_{a}^{p-1} W$ be greater than $\frac{x}{l}\sum_{a}^{b-1} W$ and $\sum_{a+1}^{p} W$ be less than $\frac{x}{l}\sum_{a+1}^{b} W$.

As a loading like Cooper's E-40 moves across a span, there will be several maxima and minima B. M.'s at any point P. The calculator of stresses cannot be certain he has used the position giving the G. B. M. (greatest bending moment) except by calculating all the maxima and using the largest. The diagram submitted herewith is intended to enable the calculator to see at a glance and without any calculation the position of the load which will give the greatest possible moment, the engines being assumed to face the left. For convenience the diagram is divided into three, so that each can be placed on an octavo page and different scales can be used on each. Diagram A is for spans from 200 to 700 ft.; diagram B for spans from 100 to 200 ft.; and diagram C for spans from 10 to 110 ft., diagrams B and C overlapping for spans from 100 to 110 ft.

To find the position of the load giving the G. B. M. at P at the distance x from A in a span of length l, find the point in the diagram whose abscissa is x and ordinate l; this point will fall in one of the areas in which the diagram is divided by heavy lines. In a circle in this area will be found the number of the wheel which must be placed at P in order to obtain the G. B. M. at P. For example, in a 250 ft. span, divided into 10 panels of 25 ft. each, the G. B. M.'s at the panel points distant 25 ft., 50 ft., 75 ft., 100 ft. and 125 ft. from the end, A will occur when wheels 4, 7, 11, 13 and 16 are at the panel points, respectively, the wheel loads being numbered from 1 to 18 inclusive.

On spans from 69 ft. to 167 ft., the G. B. M. for a point on the left of the center may be less than that at the point in the right half at the same distance from the center; for example, in a 150-ft. span divided into six panels of 25 ft. each, the G. B. M. at the panel point 50 ft. from the end will occur when wheel 7 is at that point; the G. B. M. at the corresponding panel point on other half of span, which is 100 ft. from left end, occurs when wheel 14 is at the panel point, the load facing left in both cases. The latter is the larger and is the one to be used in calculating chord stress, since the G. B. M. at a point in the right half of the span with the load facing the left is the same as the G. B. M. at that point in the left half, at same distance from center, would be when the load faces the right. Whenever a point fixed by length of span and distance from left end falls in a shaded area, it means that the G. B. M. at this point is less than that at the point in other half of same span at same distance from center of span.

For short spans (less than 60 ft.) the G. B. M. occurs sometimes under two or more wheels; in such cases it is the first wheel under which the G. B. M. occurs which is marked in the area.

The position of loading giving G. B. M. having been found from the diagram, the G. B. M. can be calculated with the help of the Moment Table or it may be found graphically. Moment tables are sometimes calculated for all the wheels except the first, or except the first and second, etc., the object being to have moment tables for cases where the first, or first and second, etc., wheels are off the span. The calculation of these additional moment tables is hardly worth while, for the B. M. can be calculated from the following formula,

$$\text{B. M.}_{\text{P}} = \frac{x}{l}\text{M}_{\text{B}} + \frac{l-x}{l}\text{M}_{\text{A}} - \text{M}_{\text{P}}.^*$$

in which M_{B}, M_{A}, and M_{P} are the moments about B, A and P, respectively, of all the loads to the left of these points, including those which may be off the span, and B. M._{P} is the B. M. at P, distant x from A.

For long spans, at distances exceeding 143 ft. from left end, the G. B. M. occurs when the beginning of the uniform load is 142 ft. from left end and is given by the following formula in m. ft. lbs. (thousand-foot pounds), for the load per rail:

$$\text{G. B. M.} = (l-x)\left(x + \frac{3800}{l}\right).^*$$

For convenience, this formula is placed on diagram A.

It is not worth while to carry the moment table beyond the beginning

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*For derivation of formulas see page 317.

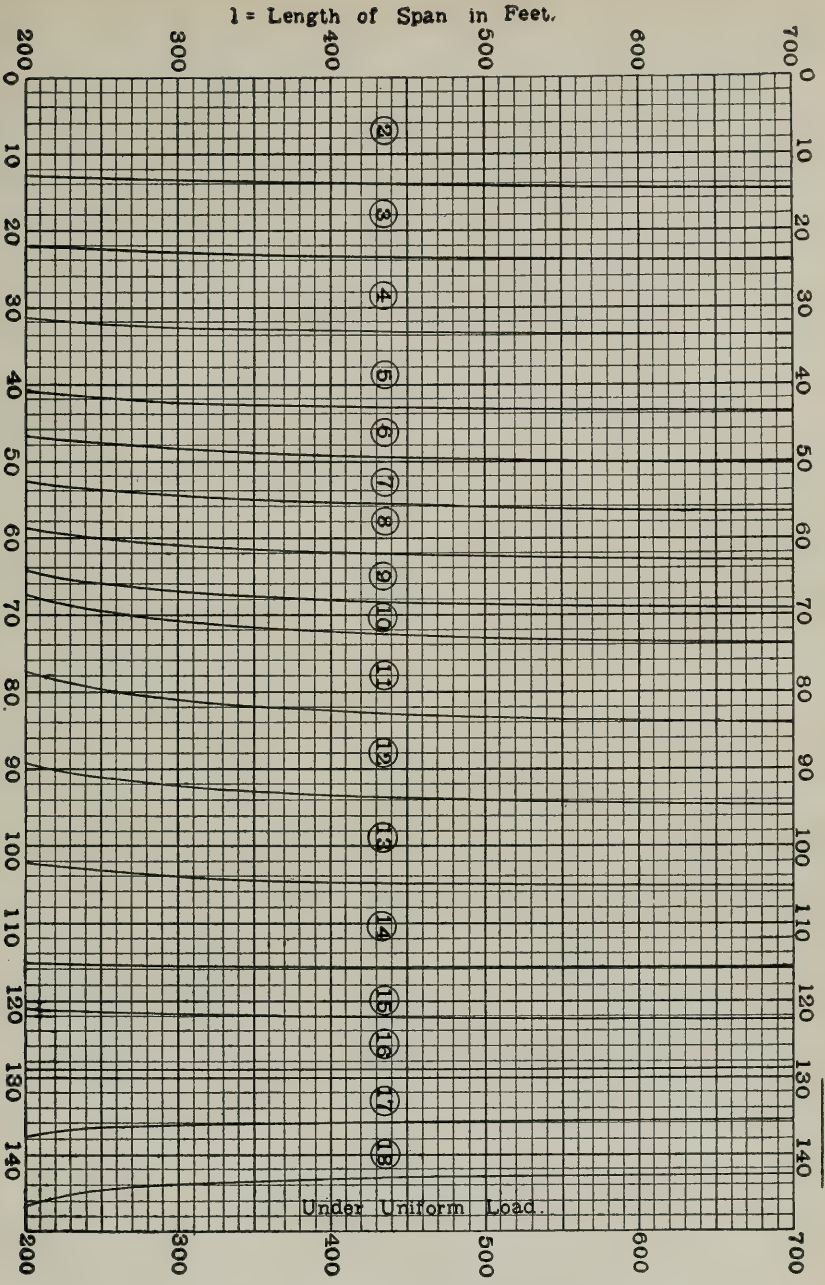

DIAGRAM A.

Note:- For Greatest Bending Moment under Uniform Load, the Uniform Load should begin 142 Feet from Left End of Span.

G.B.M. in m.ft.lbs. for Load per Rail = $x(l-x)+3800\cdot\frac{l-x}{l}$,

x being greater than 142 ft.

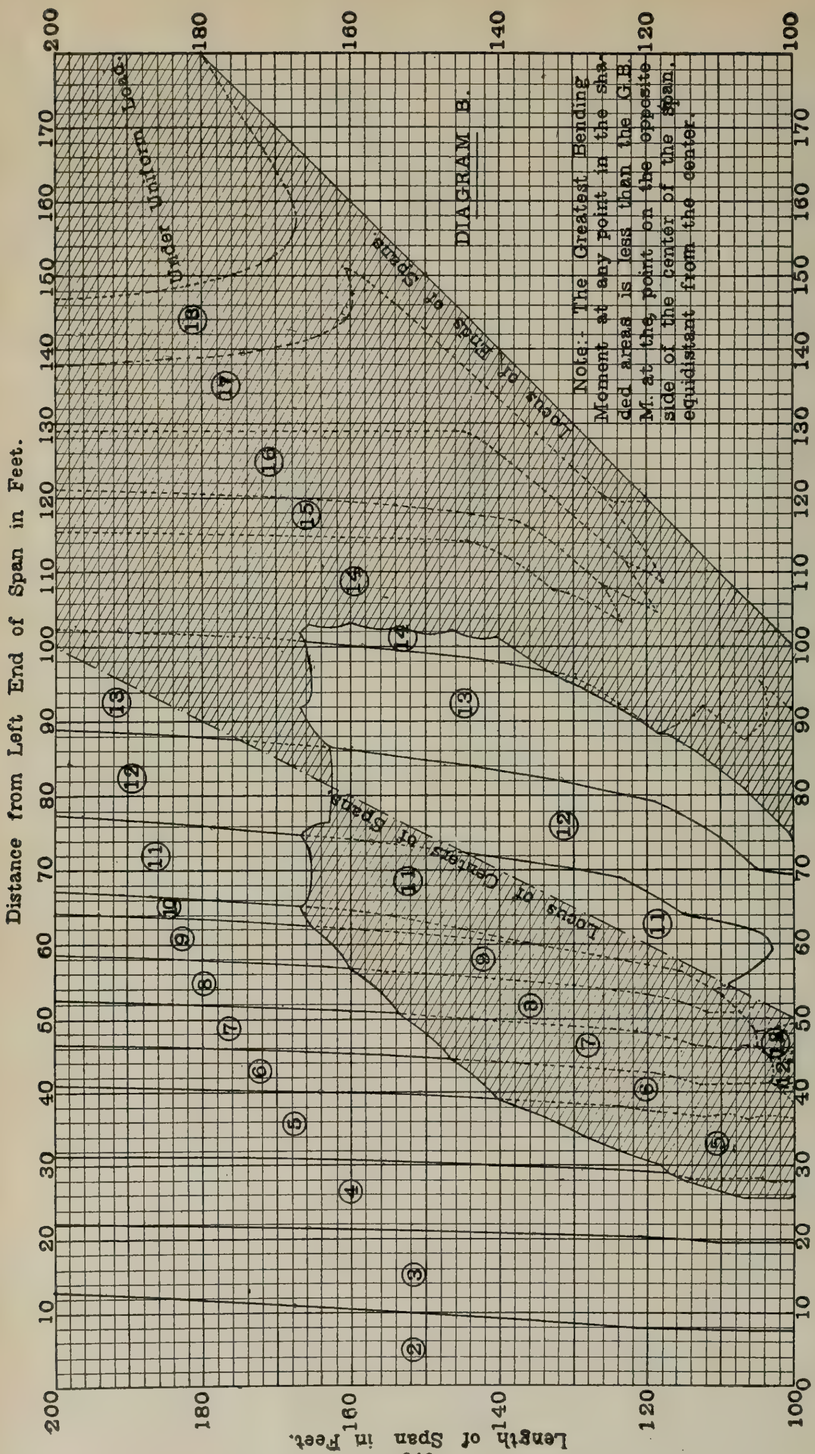
DIAGRAM B.
Note:- The Greatest Bending Moment at any point in the shaded areas is less than the G.B.M. at the point on the opposite side of the center of the span, equidistant from the center.
Distance from Left End of Span in Feet.
Length of Span in Feet.
Under Uniform Load
Locus of Ends of Spans
Locus of Centers of Spans
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
200
180
160
140
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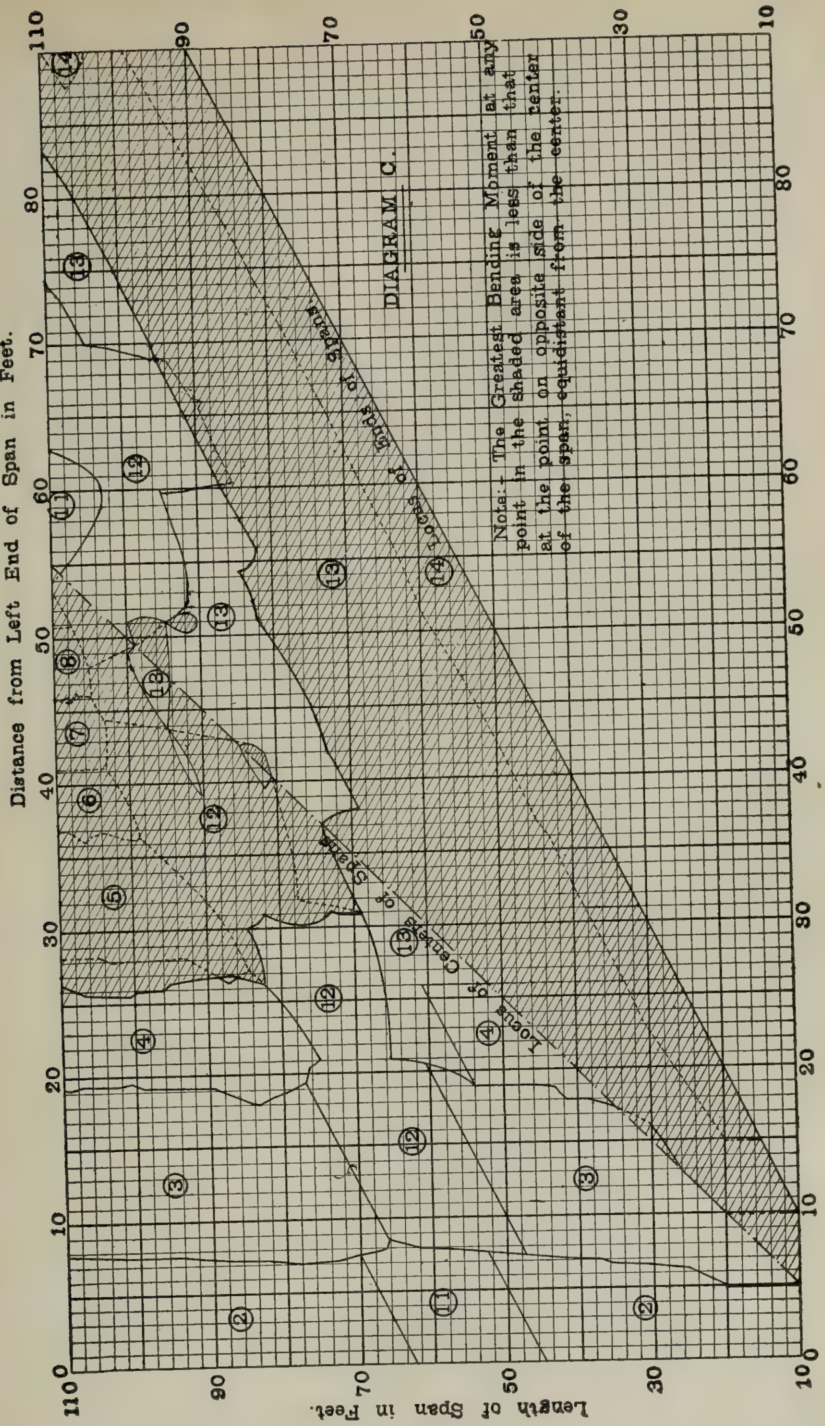

DIAGRAM C.

Note:– The Greatest Bending Moment at any point in the shaded area is less than that at the point on opposite side of the center of the span, equidistant from the center.

of the uniform load, because when B falls under the uniform load, $M_B = (l + z)^2 - 3800$*, in which $z = 33 - d_1$, d_1 being the distance of W_1 from A, positive if W_1 is to right of A and negative if to the left. By this formula M_B can be easily found with the help of a table of squares.

Diagram D gives the Moment Table, the moment being given for each foot from W_1 to the beginning of the uniform load. The division marks opposite numbers in circles give the relative positions of the concentrated loads; between successive circles is a number representing the increment of the moment for each foot which is to be used to interpolate for the moments between the ones given in the table. The part between the graduated lines is supposed to represent the slide on which the length of span is laid off and subdivided into panels, A or A^1 being the left end of the span. On the slide 33 ft. from A is a mark which gives the value of z to be used in the formula for M_B when B falls under the uniform load. By the help of the verniers on the slide, distances can be read off to tenths of a foot.

For convenience, the Moment Table below W_{10} is moved up on left of slide, so that the diagram is only one-half as long as it otherwise would be; when any of wheels 11 to 18 are to be placed less than 56 ft. from left end of span, the accented letters are to be used in place of the unaccented letters; that is, A′ is to be the left end of the span and z′ is to be the value of z. The slide should extend a distance below the A′ on the right edge of slide to enable another z′ to be marked on it at a distance of 33 ft. from A′, so that as the z′ on left edge of slide moves off the scale at the top, the z′ on right edge comes on to the scale at the bottom. The writer has found it convenient to paste the table on a double thickness of cardboard, the part of the top cardboard between the graduated lines being cut out for a recess in which to place the slide. The convenient moment slide rule just described can readily be made up from the diagram (insert) which accompanies this paper. Such slide rule is illustrated in the photograph, Fig. 1.

Should the table be made as described above, the scale on left edge of diagram D is of no use and can be cut off along the dotted line. Should a single length of table be preferred, the part of table on left of diagram D can be cut off between the moments and the graduated part on the right of the moments and pasted so as to form a continuation of the part of the table on the right, the graduated left edge of diagram D forming then a continuation of the right graduated line of the diagram.

A few examples of the calculation of the G. B. M. may be of service. Take a span of 300 ft. divided into 12 panels. Diagram A shows that at the center the G. B. M. occurs when the center is under the uniform load, the beginning of the uniform load being 142 ft. from left end of span. The formula for this case gives us

G. B. M. at center $= 150\,(150 + 12\tfrac{2}{3}) = 24{,}400$ m. ft. lbs.

At the panel point 75 ft. from left end diagram A shows that the

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*For derivation of formulas see page 317.

G. B. M. occurs when W_{11} is at that panel point. Putting the mark on the slide for this panel point under W_{11}, the right end of the span is under the uniform load; the slide gives us $z = 22$, hence by formula $M_B = 322^2 - 3{,}800 = 99{,}884$ m. ft. lbs.; the slide also shows that $M_A = O$ and that $M_P = 5{,}848$ m. ft. lbs.; hence, G. B. M. at this point $= \frac{3}{12} . 99884 - 5848 =$ 19,123 m. ft. lbs.

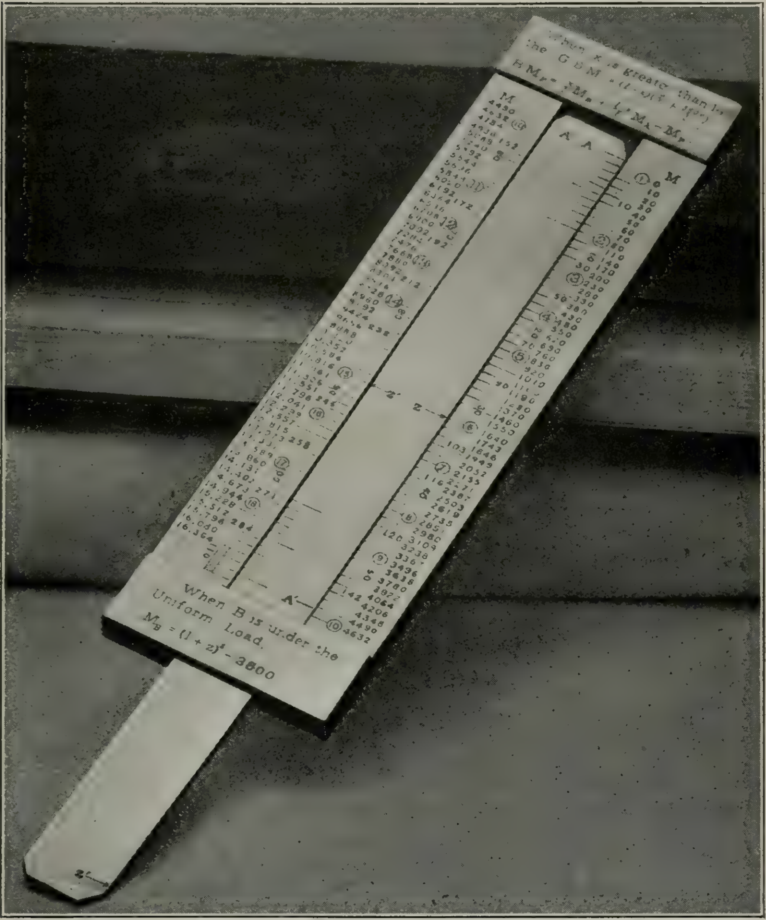


FIG. I.

Next take a 150-ft. span and determine the G. B. M.'s 50 ft. and 100 ft. from left end; by diagram B, the G. B. M. at first point occurs when W_7 is at the point and at the second point when W_{14} is at the second point. For the first case it will be found by the slide that $M_A = O$, $M_P = 2{,}155$

m. ft. lbs. and $z = 20$; hence, $M = 170^2 - 3{,}800 = 25{,}100$ m. ft. lbs. and G. B. M. 50 ft. from left end $= \frac{1}{3}.25{,}100 - 2{,}155 = 6{,}212$ m. ft. lbs.

For the second point in this span the slide shows that $M_A = O$, $M_P = 8{,}728$ m. ft. lbs. and $z = 12$; hence, $M_B = 162^2 - 3{,}800 = 22{,}444$ m. ft. lbs. and

G. B. M. 100 ft. from left end $= \frac{2}{3}.22{,}444 - 8{,}728 = 6{,}235$ m. ft. lbs.

For a final example let it be required to find the G. B. M. at the center of a 65-ft. plate girder. Diagram C shows that the G. B. M. occurs at this point when W_{13} is at the center. The slide will give the following quantities, $M_A = 2{,}610 + \frac{1}{2}.116 = 2{,}677$ m. ft. lbs.; $M_P = 7{,}668$ m. ft. lbs.; $M_B = 15{,}512 + \frac{1}{2}.284 = 15{,}654$ m. ft. lbs., and for this case

G. B. M. $= \frac{1}{2}.15{,}654 + \frac{1}{2}.2{,}677 - 7{,}668 = 1{,}497.5$ m. ft. lbs.

In conclusion, attention may be called to the fact that the equation for G. B. M. for the cases where this occurs under the uniform load in spans divided into *n* equal panels each of length *p*, may, if $x = mp$, be put in the form

$$\text{G. B. M.} = (n - m)\left(m\,p^2 + \frac{3800}{n}\right).$$

DERIVATION OF FORMULAS.

With the notation explained in the paper, M_B is the moment about B of all the loads to the left of B; M_A is the moment about A of all the loads to the left of A; hence, the moment about B of all the loads to the left of A is $M_A + l\sum_1^a W$, and therefore the moment about B of *all the loaas on the span* is $M_B - M_A - l\sum_1^a W$; this divided by l is the reaction at A. Similarly the moment about P of all the loads on the span between A and P is $M_P - M_A - x\sum_1^a W$. Consequently,

$$\text{B. M.}_P = \frac{x}{l}\left(M_B - M_A - l\sum_1^a W\right) - \left(M_P - M_A - x\sum_1^a W\right) = \frac{x}{l}M_B + \frac{l-x}{l}M_A - M_P \quad \ldots\ldots (1)$$

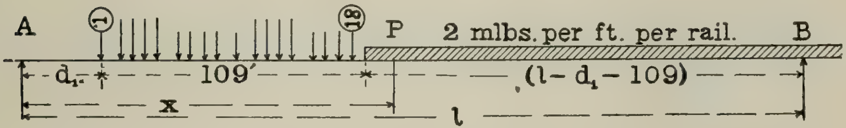


FIG. 1.

Suppose that B is under the uniform load as in Fig. 1. Then since the uniform load is 2,000 lbs. per ft. per rail.

$$M_B = 16{,}364 + (l - d_1 - 109)284 + (l - d_1 - 109)^2$$
$$= 16{,}364 + [142 + (l - d_1 - 109)]^2 - 142^2 = (l + 33 - d_1)^2 - 3800 = (l + z)^2 - 3800 \quad \ldots\ldots (2)$$

Next suppose both P and B to be under the uniform load; for G. B. M at P the average load on AP must be the same as that on BP; hence, the beginning of the uniform load must be at the distance 284/2 = 142 ft. from A; hence, $d_1 = 142' - 109' = 33'$ and z in (2) equals zero; hence for this position of the load $M_B = l^2 - 3800$. P being also under the uniform load at distance x from A, M_P can be obtained by substituting x for l, z being zero as before; hence, $M_P = x^2 - 3800$. For this position of the load $M_A = 0$. Substituting these values of M_A, M_P and M_B in (1) we have

$$\text{G. B. M.}_P = \frac{x}{l}(l^2 - 3800) - (x^2 - 3800) = x(l - x) + 3800\frac{l-x}{l} =$$
$$= (l - x)\left(x + \frac{3800}{l}\right) \quad \ldots\ldots (3)$$

If the load on each driver axle be E mlbs. instead of 40 mlbs., stresses can be calculated for the loading treated in this paper and multiplied by E/40; or the correction may be made at same time as allowance is made for impact by multiplyiug the stresses by $\frac{E}{40}\left(1 + \frac{300}{L + 300}\right)$.

DISCUSSION.

(The report on Iron and Steel Structures was presented by the Chairman, Mr. C. H. Cartlidge, Bridge Engineer, Chicago, Burlington & Quincy Railroad.)

The President:—The Committee asks approval for certain changes in the adopted specifications for Steel Railway Bridges, and the changes will be stated by the Chairman.

Mr. Cartlidge:—The Committee on Iron and Steel Structures held a joint meeting with the Roadway Committee for the purpose of reconciling the specifications for clearances in bridges and tunnels, as instructed by the Board of Direction. The joint meeting concluded to recommend the insertion in clause 2 of the Specifications for Steel Railway Bridges, as printed in the edition of 1910, after the word "diagram" on the second line: "The height of the rail shall, in all cases, be assumed as 6 in."

In its report the Committee calls attention to certain typographical errors which are of minor importance, and presumably no action is required on the part of the convention.

Your Committee, therefore, asks that the above change in clause 2 be approved and authority given for making the minor corrections set forth in the report.

The President:—If there are no objections, the addition to the Specifications for Steel Railway Bridges, as stated by the Chairman, and the corrections indicated in the report will be approved.

We will next take up the specifications for the erection of railway bridges. Since the report has been put in print, the Committee has made some changes which will be indicated by the Chairman as we come to them. The Secretary will read the specifications item by item.

The Secretary:—"1. Work to Be Done. The contractor shall erect and adjust all steel work, ready for use.

"2. Plant. The contractor shall provide all tools, machinery, appliances and outfit necessary for the expeditious handling of the work.

"3. False-Work. The contractor shall submit general working plans sufficient to show the proposed method of erection. When the false-work is to be built by the contractor, he shall submit the design of the temporary structure for the approval of the engineer. The work shall not proceed until these erection plans have been approved in writing, but such approval shall not relieve the contractor from any responsibility. False-work material will be provided by the Railroad Company.

"The temporary structure for use during erection and for maintaining the traffic shall be properly designed and substantially constructed for the loads which shall come upon it. All bents shall be thoroughly secured against movement, both transversely and longitudinally. The bents shall be well secured against settling, and piles used wherever firm bottom cannot be obtained. Upon completion of the erection the temporary structure shall be removed without unnecessary damage, and neatly piled near the site or loaded on cars, as may be directed.

"False-work placed by the Railroad Company under an old structure or for carrying traffic temporarily over a new opening, may be used by the contractor during erection, provided it is not unnecessarily cut and wasted."

Mr. Cartlidge:—In the first clause of the section we desire to interpolate a sentence after the word "erection;" in the second line, a new sentence reading: "False-work will be built by *..............." In the last line, in that clause, the words "Railroad Company" to be replaced by a blank space. In the last clause in this section, interpolate in the second line, between "used" and "by," "as far as practicable," so that this sentence will read, "falsework placed by the railroad company under an old structure or for carrying traffic temporarily over a new opening may be used as far as practicable by the contractor during erection, provided it is not unnecessarily cut and wasted." Each one of these blank spaces is to have a dagger referring to the footnote at the bottom of the page, as fololws: "*Insert 'Railroad Company' or 'contractor,' as the case may be."

The President:—If there are no objections, the changes stated by the Chairman will be approved.

The Secretary:—"4. Conduct of Work. The work shall be prosecuted with sufficient force, plant and equipment to expedite its completion to the utmost extent and in such a manner as to be at all times subordinate to the use of the tracks by the Railroad Company, and so as not to interfere with the work of other contractors or to close or obstruct any thoroughfare by land or water, except under proper authority.

"Tracks shall not be cut except when authorized by the Engineer, and trains shall not be subjected to any delay other than a reduction of speed, except when special authority shall have been obtained from the Railroad Company.

"The contractor shall protect traffic and his work by flagmen, furnished by the Railroad Company at the expense of the contractor, and he shall provide competent watchmen to guard the work and material against injury."

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I do not like the wording of the second paragraph. It requires the contractor to get authority for cutting tracks from the engineer, and in the last line to ask for certain other authority from the Railroad Company. I think the contractor should look to the same person for all the information and direction necessary in the conduct of his work. I would move, therefore, that this clause be changed to read, "Tracks shall not be cut, nor shall trains be subject to any delay other than a reduction of speed, except when authorized by the engineer."

The President:—The Committee accepts that amendment.

Mr. C. H. Spencer (Washington Terminal) :—Would this allow the contractor to cut the tracks?

The President:—Not without permission of the engineer.

Mr. C. H. Spencer:—I do not think it is good policy to have anyone but the Maintenance of Way force cut the tracks or in any way change the tracks. It seems to me that at least should be done under the supervision of the engineer. I would like to see that changed to read, "except under the supervision of the engineer."

The President:—Mr. Spencer, will you kindly indicate how you would like to have that clause read?

Mr. Spencer:—Aside from Mr. Loweth's recommendation, I would like to have that read, "tracks shall not be cut except under the supervision of the engineer." In other words, I do not believe the mere authority of the engineer for cutting the tracks is sufficient. It should be done under his supervision and inspection.

The President:—Is that acceptable to you, Mr. Loweth, as part of your amendment?

Mr. Loweth:—I do not think the engineer would authorize such a thing to be done without hemming it around with such safeguards as might be necessary. There may be cases, especially on unimportant tracks, where it would be quite proper to allow the contractor to cut the track. If he is required first to obtain authority, the engineer can prescribe the necessary precautions.

The President:—The Committee accepts the suggestion of Mr. Lowetc, and will so amend the clause.

Mr. Thomas Earle (Pennsylvania Steel Company) :—In the first clause it says, "and so as not to interfere with the work of other contractors." In doing work of that kind, if there are two or three contractors, it is unavoidable that one will interfere with the other, and as the work is done under the supervision and in accordance with the directions of the engineer, it seems to me it would be better to leave those words out.

The President:—The Committee is not willing to accept that.

Mr. W. F. Steffens (Boston & Albany) :—In the last clause of paragraph 4 is the usual flagman provision. On some railroads there is a question of the responsibility of the flagmen involved, and their contracts provide that the flagmen shall be the servants of the contractor, in order to concentrate responsibility.

The President:—Any further discussion? If not, we will proceed to clause 5.

The Secretary:—"5. Engine Service. When worktrain or engine service is furnished the contractor free of charge, such free service shall consist only in unloading materials and in transferring the same from a convenient siding to the bridge site. When such service is desired, the contractor shall give the proper railroad officials at least 24 hours' advance notice, and the Railroad Company will furnish the service as promptly as possible, consistent with railroad operations.

"When derrick cars are used on main tracks, their movements will be in charge of a train crew, and the expense of this crew and any engine service other than as noted above shall be charged to the contractor."

Mr. Loweth:—I think that the two clauses of article 5 may, at times, be in conflict. It is provided in the first clause that work-train service for unloading material and transferring from siding to bridge site will be furnished free. Frequently material is unloaded from the cars in which it was shipped from the shops and put directly into the structure, and sometimes it is taken from the nearest yard or siding and put into place in the structure. There would be doubt as to whether free work-train service was to be furnished in these cases. Again, the operations just referred to may be by derrick cars, in fact frequently are, and the wording of the second clause would in such cases conflict with the first. I think there should be a more definite statement as to work-train charges.

Mr. J. P. Snow (Boston & Maine):—I have found it necessary, in cases such as Mr. Loweth has instanced, to make an estimate of what would be a fair charge for unloading, on the supposition that the whole carload was unloaded beside the track promptly—I do not know how the clause can be changed with benefit, if the material is put in place. Of course, the contractor must not expect he is going to have free service while he is erecting his bridge; and in that case you can simply make an estimate of how long it would take the train crew to unload the material in the ordinary way. I think the clause is pretty good as it stands. The word "only" helps the matter out.

The President:—Mr. Loweth, have you in mind any suggestion to modify those clauses?

Mr. Loweth:—It would take a pretty general overhauling of the clauses to eliminate the ambiguity. There may be no conflict with certain methods which the contractor might adopt for handling his work, but with some other methods used quite extensively, there certainly would be ambiguity as to the extent of the free work-train service to be furnished the contractor. I think the Committee can readily eliminate the difficulty, now that attention has been called to it.

Mr. H. T. Porter (Bessemer & Lake Erie):—Clause 5 begins, "when work-train or engine service is furnished the contractor free of charge"—I would like to suggest omitting the words "free of charge." Then follows: "Such free service shall consist only in unloading materials and in transferring the same from a convenient siding to the bridge site." I would like to suggest omitting the word "free." This service, under the Interstate rules, I understand, cannot be furnished unless it is a part of the contract by which the structure is furnished, so that it is not necessary here to know whether it is free or whether it is to be paid for, but is simply a guide in showing what kind of service should be furnished to the contractor, which may either be paid for by the contractor or may be furnished free, in accordance with the contract, so that it would read: "When work-train or engine service is furnished the contractor, such service shall consist only in unloading materials, and in transferring the same from a convenient siding," etc. Then follows the clause which shows the notice necessary to give the company.

The President:—The Committee is not willing to accept that. Are you willing to offer an amendment, Mr. Porter?

Mr. Porter:—No, I will let it go.

Mr. C. E. Smith (Missouri Pacific):—In general, the cost of work-train service in connection with bridge erection forms a large part of the cost. From an economic standpoint, it is desirable to promote the use of self-propelling apparatus by contractors and also by railroad companies. An erection contractor is now working on our lines under a contract that provides no work-train service on branch lines, and the contract price was increased only slightly by that provision. I think it is desirable to cut out the work-train service entirely from the contract. The time of 24 hours for notice when work-train service is desired appears too short. We find we cannot get a work train to any one point on 24 hours' notice.

The President:—The clause reads: "At least twenty-four hours' notice." You can have as much as you please.

Mr. Loweth:—I move that clause 5 be referred back to the Committee for further consideration.

Mr. Cartlidge:—The Committee will, of course, accept the work placed upon it, but it would be very much obliged to Mr. Loweth for an expression of opinion as to the changes to be made. The Committee has gone over the matter as carefully as it could, and we fail to see what is intended in the way of change, and if Mr. Loweth will communicate with the Committee, we will be very glad, indeed, to consider his proposition.

Mr. F. E. Schall (Lehigh Valley):—It appears to me that this Committee should put some kind of a limit on the free transportation service furnished by the Railroad Company. The contractor might take advantage of the unlimited time for this service and unload the material as most convenient for erection, irrespective of the expense to the Railroad Company. The most satisfactory way is to let the contractor pay for any transportation service rendered for delivering the material to the nearest station and also for transporting it to the site.

The President:—The Committee claims to have met that situation by stating that free service shall be furnished only in the unloading of material. The question is on Mr. Loweth's motion to refer back to the Committee.

(The motion carried.)

The Secretary:—"6. Transportation. When transportation of equipment, materials and men is furnished free over the Railroad Company's line, it shall be subject to such conditions as may be stated in the contract."

The President:—Mr. Porter, that covers your suggestion that the contract shall govern in the matter of free transportation. If there is no discussion, we will pass on to the next.

The Secretary:—"7. Masonry. The Railroad Company will finish all masonry to correct lines, and elevations, and unless otherwise stated in the contract, will make all changes in old masonry without unnecessarily impeding the operations of the contractor. The Railroad Company's engineers will establish lines and elevations, but the contractor will compare the elevations, distances, etc., shown on plans with the masonry as actually constructed so far as practicable, before he assembles the steel. In case of discrepancy, he shall immediately notify the engineer."

Mr. Steffens:—I should like to see the second sentence stricken out, so that it will simply read: "The Railroad Company's engineers will establish lines and elevations." Let it stop there; eliminate the rest of it.

The President:—The Committee makes the point that it is not advisable to eliminate this, because they want the contractor to check the measurements and be a check on the work.

Mr. Snow:—Does the Committee desire that the contractor shall send an engineer with instruments, etc., to check elevations and distances?

Mr. Cartlidge:—In the original draft of this article there appeared some reference to the use of a carpenter's level and a steel tape, so we put in here that he use such appliances as he has at hand, which which to check and satisfy himself that there is no gross error and that his own measurements and preparations are adequate.

Mr. C. E. Smith:—It has been my experience that unless you have that clause in the contract with a penalty attached to it, the contractor will go ahead with the work until he finds a discrepancy, and then will notify the engineer; unless you put in a clause to make him responsible for the checking, he will not be so careful. I think the clause should be changed as Mr. Steffens has moved that it be changed.

(The motion carried.)

The President:—Everything will be eliminated in clause 7 after the word "elevations."

Mr. A. F. Robinson (Santa Fe):—This clause is intended to prevent long delays or the getting out of a lot of material onto a bridge for assembling, only to find out, after they get a couple of hundred tons of metal stretched out, that the distance between parapet walls is incorrect, or something is incorrect. The engineer who has established the levels and the lines is usually not on the ground when the superstructure is erected, and what was intended in the specification was advice to the contractor that before he commences running out iron onto his false-work, he should make his necessary rough checks to see whether the distance from base of rail to masonry would allow his iron to go on in or whether he could get his iron in between the parapet walls or on the piers.

Mr. C. E. Smith:—In further reply to Mr. Robinson, I would like to state a case that happened on the main line of the Iron Mountain about three years ago. A contractor was putting in a small bridge, I think a 36-ft. lift span. The contract provided that the contractor was to check the masonry work before he started work. He slid the old span out, and tried to get the new span in, but could not because the steel was a little bigger than the opening. The main line was tied up about twelve hours. I do not doubt that there are other members who could give similar experiences.

There was no redress against the contractor, because the specifications simply said he should "check."

Mr. Cartlidge:—It occurs to me the difficulty was not with the specifications, but with the failure to enforce them.

The President:—The Chairman wishes to go back to clause 7 and make a slight change.

Mr. Cartlidge:—The amendment, which was passed on Mr. Steffens' motion, provides for the elimination of the whole of the last sentence but one, and the last sentence, after the word "elevations" in the fifth line. It seems to me there is a repetition there.

Mr. Steffens:—The second sentence states that the railroad engineers shall give those lines.

Mr. Cartlidge:—I move that the words, "the railroad company's engineers will establish lines and elevations," beginning with the fourth line, be omitted.

Mr. C. A. Morse (Santa Fe):—I do not think we ought to do that. We build the masonry, and there should be a center line on the abutments for the bridgemen, when they come to put in the iron work I do not care anything about the elevation, but I think a center line should be established.

Mr. Cartlidge:—I think that is implied in the first, and that the second reading is simply a repetition of what is said in the first line of the first sentence.

Mr. Snow:—We have referred one of these things back to the Committee. Why would it not be best to refer No. 7 back also and let them see if they cannot introduce a requirement somehow, so that the contractor shall have a little responsibility? If it is in order, I will move that clause 7 be referred back to the Committee.

The President:—The Committee accepts that suggestion.

The Chairman withdraws his motion to strike out that sentence and is willing to accept Mr. Snow's suggestion to have it referred back to the Committee, and if there is no objection the matter will stand in that way.

The Secretary:—"8. HANDLING AND STORING MATERIALS. Cars containing materials or plant shall be promptly unloaded upon delivery, and the contractor shall be liable for demurrage charges. Materials shall be placed on skids above the ground, laid so as not to hold water, and stored and handled in such a manner as not to be injured or to interfere with railroad operations. The expense of repairing or replacing material damaged by rough handling shall be charged to the contractor. The contractor, while unloading and storing material, shall compare each piece with the shipping list and promptly report any shortage or injury discovered."

Mr. C. E. Smith:—Clause 8 appears to assume that all the material will be unloaded by the contractor. While this is possible in the case of one or two bridges of considerable tonnage, it is not likely to be economical in the case of a large number of bridges of small tonnage, for the contractor will run up excessive charges by having his men running around from point to point. I move that there be inserted at the beginning of the third line preceding the word "materials" the following: "Where steel work is to be unloaded by the contractor, the material shall be placed on skids above the ground," etc.

Mr. Snow:—I ask Mr. Smith if it is not a good idea for the railroad people to put that stuff on skids?

The President:—The Committee is not willing to accept that amendment.

Mr. Steffens:—This sentence, as it now stands, makes a contractor liable for demurrage charges, even when, as Mr. Smith cites, the railroad company is under obligations to unload. Frequently, however, the railroad does not unload the material.

The President:—Does the Committee understand that Mr. Steffens would suggest, in case the unloading is to be done by the railroad company and the car is unduly delayed, that the contractor would be held by the railroad company for demurrage charges? We would like to know if it is Mr. Steffens' idea if the railroad company assumes the work of unloading material and unduly delays the cars, if it would attempt to collect demurrage charges under this specification?

Mr. Steffens:—There is nothing in the first sentence to prevent that.

The Secretary:—"9. MAINTENANCE OF TRAFFIC. When traffic is to be maintained, it will be carried on in such a manner as to interfere as little as practicable with the work of the contractor.

"Changes required during erection shall be at all times under the direct control and supervision of the Railroad Company. Any changes desired to be made by the Railroad Company for insuring greater safety to traffic shall be made by its own forces, and no claim on the part of the contractor for delay or damage on account of such changes will be allowed."

The President:—In the second paragraph of clause 9, beginning with the word "any," in the next to the last line, the Committee proposes to eliminate the sentence "any changes desired to be made by the Railroad Company for insuring greater safety to traffic shall be made by its own forces." We also omit the word "and" and begin the sentence "no claim on the part of the contractor for delay or damage on account of such changes will be allowed."

If there is no further discussion or motion on the subject, we will proceed to clause 10.

The Secretary:—"10. REMOVAL OF OLD STRUCTURE. Metal work in the old structure shall be dismantled without unnecessary damage. and loaded on cars or neatly piled at a site immediately adjacent to the tracks, and at a convenient grade for future handling, as may be directed. When the structure is to be used elsewhere all parts will be matchmarked by the Railroad Company; when the old bridge is composed of several spans the parts of each shall be kept separate."

Mr. Steffens:—The first sentence of No. 10 implies that all structures are to be used again; that is, shall be dismantled without unnecessary damage. The second sentence begins "when the structure is to be used elsewhere," implying that, under some circumstances, the contrary might be true. It would be well to have the first sentence begin, "unless otherwise ordered," as a large number of old bridges taken out to-day are scrapped immediately, burned apart and taken down in all sorts of ways. There is a conflict of ideas between the two sentences as they now stand.

The President:—The Committee thinks that is immaterial. Do you want to make a motion to that effect?

Mr. Steffens:—I move that the words "unless otherwise ordered" be inserted before the first sentence.

Mr. H. A. Lloyd (Erie):—That seems to me unnecessary. This matter is going back to the Committee, and the Committee has our suggestions as to the changes, and we do not need to decide here whether this change or that change shall be made.

Mr. Steffens:—I do not desire to urge my motion. It was made as the result of the President's suggestion.

The Secretary:—"11. Steel Work. Steel work shall be handled without damage or abuse. Threads of all pins shall be protected by pilot and driving nuts while being driven in place.

"Light drifting will be permitted in order to draw the parts together; but drifting for the purpose of matching unfair holes shall not be permitted. Unfair holes shall be reamed or drilled.

"Nuts on pins and on bolts remaining in the structure shall be effectively locked by checking the threads.

"All splices and field connections shall be securely bolted prior to riveting. When the parts are required to carry traffic, important connections, such as tension splices and attachments of stringers and floor beams, shall have at least fifty (50) per cent. of the holes filled with bolts, and twenty-five (25) per cent. with drift pins; or else, seventy-five (75) per cent. filled with bolts. When not carrying traffic, at least thirty-three and one-third (33⅓) per cent. of the holes shall have bolts.

"Rivets in splices of compression members shall not be driven until the members shall have been subjected to the full dead load stresses. Rivets shall be driven tight. No re-cupping or calking will be permitted. The heads shall be full and uniform in size, free from fins, concentric and in full contact with the metal. Heads shall be painted immediately after acceptance.

"Rivets shall be uniformly and thoroughly heated and no burnt rivets shall be driven. All loose rivets shall be promptly cut out and re-driven. In removing rivets the surrounding metal shall not be injured; if necessary, the rivets shall be drilled out."

The President:—The Committee desires to change the words, "steel work," in the first line to "material."

Mr. William McNab (Grand Trunk):—Will the Committee consent to eliminate the words "or abuse" at the end of the first sentence?

The President:—The Committee accepts that.

Mr. Steffens:—I should like to ascertain the views of the members as to whether it is good practice to depend entirely on bolts alone, without pins, to carry traffic?

There is nothing stated relative to additional rivets required beyond the usual number, plus the excess. Also, if the contractor loses a considerable number of rivets, whether the rivets that he needs to finish the structure should not be furnished at his own expense. It seems that this idea should be incorporated as a final clause.

Mr. Cartlidge:—Mr. Steffens' suggestion as to the limit of rivets is well taken, and the Committee will incorporate it in a reconsideration of the specifications.

The Secretary:—"12. MISFITS. Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins, and a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Engineer, and the work of correction done in the presence of the Engineer, who shall check the time expended. Minor misfits and a reasonable amount of reaming shall be considered as a legitimate part of the erection, but misfits and badly matched holes, which require drilling or cutting apart, shall be chargeable to the manufacturers."

Mr. W. H. Courtenay (Louisville & Nashville):—What particular individual is meant by the Engineer in clause 12?

The President:—That is specified in clause 22.

Mr. Courtenay:—It frequently happens that there are minor misfits in bridges, and it does not seem to me to be necessary to specify that the Engineer or his accredited representative shall always be there to actually watch the rectification of the minor misfits; they are reported to the Engineer's office, and he can take such steps in connection with the matter as he considers necessary. The question for debate is whether the man shall stand there and see the mechanical work done. I want to know if that is the idea of the Committee.

Mr. Cartlidge:—That is the idea of the Committee—the presence of the Engineer during the correction of minor misfits is not necessary, but there are many cases when the Engineer's presence is necessary when misfits of a major character are being remedied. The Committee feels that that is a point which should be watched by the Engineer, and that it is good practice to recommend that it be done.

Mr. Steffens:—Is it necessary to specify that the hole shall be drilled after the metal is placed? There are certain examples I personally know of where it was a decided advantage to drill them in advance, where it was not contemplated to imbed the bolts in the masonry at that time. The holes were drilled in advance of the erection of the steel work.

Mr. Cartlidge:—There is no rule without its exceptions. It is very likely that some occasions might arise in which it is preferable to drill holes in the masonry before the steel work is set, but it is undoubtedly a fact that there are a thousand cases where the contrary is the fact, and we cannot, in a specification as general as this, cover all the little variations in conditions which may occur.

Mr. Steffens:—Will the Committee insert the words, "in general," to cover the case?

The President:—The Committee is not willing to accept that change.

The Secretary:—"13. ANCHOR BOLTS. Holes for all anchor bolts, except where bolts are built up with the masonry, shall be drilled by the contractor after the metal is in place, and shall be set in Portland cement grout.

"14. BED PLATES. Bed plates resting on masonry shall be set level and have a full, even bearing over their entire surface; this shall be attained either by the use of Portland cement grout or mortar, or by tightly ramming in rust cement under the bed plates after blocking them accurately in position."

Mr. Loweth:—I hope in reconsidering this that the Committee will provide for the use of sheet lead between masonry and bed plates.

Mr. Steffens:—I hope in reconsidering this, the Committee will see fit to omit the clause relating to bed plates. This matter again is one that depends upon the accuracy of the engineering.

Mr. Cartlidge:—The Committee considered the use of sheet lead and decided that the experience of the Committee was against it. Of course, the Committee is the servant to the Association, and if the Association desires that the use of sheet lead is desirable, we will so provide in the specifications. With reference to Mr. Steffens' criticism, this question is entirely apart from the levels of the masonry or the position of the castings. It is something which provides an accurate bearing for bed plates upon a more or less roughened surface. It is impossible to make the bed plate and bridge seat so smooth as to form an ideal bearing surface and the use of a joint between the casting and a bridge seat is good practice.

The Secretary:—"15. DECKS. The Railroad Company will place the permanent deck."

The President:—The Committee recommends the elimination of the words "The railroad company," and insert a blank space with the footnote as in clause 3, and the insertion of the words "frame and" between the words "place" and "the."

If there is no further discussion on clause 15 we will proceed.

The Secretary:—"16. PAINTING. The paint shall be furnished by the contractor, and shall be of such color, quality and manufacture as may be specified.

"Surfaces inaccessible after erection, such as bottoms of base plates, tops of stringers, etc., shall receive two coats of paint before assembling in place. After erection the entire structure shall receive two coats of paint, allowing enough time between coats for the first coat to dry before applying the second. No paint shall be applied in wet or freezing weather, nor when the surface of the metal is damp. Painting shall be done in a good and workmanlike manner, subject to strict inspection during progress and after completion, and in accordance with special instructions which will be given by the Engineer. All metal shall be thoroughly cleaned of dirt, rust, loose scale, etc., before the paint is applied."

The President:—The Committee has one change to make, the word "contractor" in the first line to be changed to a blank.

Mr. McNab:—In regard to the first clause of 16, it states "the paint shall be furnished by ...." I would like to ask if the Committee is satisfied with this as it stands—by whom are these things to be specified?

Mr. Cartlidge:—We have understood that the arbiter in any controversy between the Railroad Company and the contractor is the Engineer. That is stated in all contracts.

Mr. C. A. Morse:—Under this clause there is nothing that would prevent the contractor painting the bridge with a spraying machine.

Mr. Cartlidge:—The work is to be done in accordance with special instructions which will be given by the Engineer.

The Secretary:—"17. CLEARING THE SITE. The contractor, after completion of the work of erection, shall remove all old material and debris and place the premises in a neat condition."

Mr. Steffens:—I would like to see clause 17 changed to read, instead of "a neat condition"—"as good condition as he found them."

Mr. Cartlidge:—The Committee thought of that and considered the case also in which the contractor would use a temporary trestle built by the railroad company and provides herein for the removal of that trestle by the contractor. Similar cases of infinite variety may arise. We do not think the provision of this clause is such that it will work any hardship on the contractor.

The Secretary:—"18. SUPERINTENDENCE AND WORKMEN. During the entire progress of the work the contractor shall have a competent superintendent in personal charge and shall employ skilled and competent workmen. Instructions given by the Engineer to the superintendent shall be carried out the same as if given to the contractor. If any of the contractor's employes, by unseemly or boisterous conduct, or by incompetency or dishonesty, show unfitness for employment on the work, they shall, upon instructions from the Engineer, be discharged from the work, nor thereafter be employed upon it without the Engineer's consent."

The President:—The Committee has a change in the second line, between the words "employ" and "skilled" the word "only" is inserted.

The Secretary:—"19. INSPECTION. The work of erection shall at all times be subject to the inspection and acceptance of the Engineer.

"20. RESPONSIBILITY. The contractor shall assume all responsibility for loss or damage to his own work, materials or plant, due to any cause whatsoever; also, for all loss or damage to the Railroad Company's materials or property, and to other property adjacent to the railroad, due to causes within his reasonable control.

"He shall assume all responsibility for injury to the workmen or the public, or to any individual; and in case of accident or suit he shall defend the suit in person and relieve the Railroad Company from all costs and expenses, and pay any judgments that may be recovered thereon.

"He shall comply with the local and government laws and ordinances affecting the manner of doing work; shall take out all necessary permits and comply with their requirements, and shall take such precautions as may be necessary to protect life and property."

Mr. McNab:—This clause says he shall assume all responsibility for injury to the workmen or the public. It would be better language to say "to the workmen and the public"—leave out the word "or."

The President:—The Committee accepts that.

Mr. Snow:—I would like to ask the Committee if the sentence in the last paragraph of clause 20, reading "he shall comply with the local and government laws," could not well be omitted. I cannot see the necessity of saying that a man shall conform to the laws of the land.

Mr. Cartlidge:—It seemed to the Committee that while it is not necessary to command a man to be good, we do think it is necessary to call his attention to the fact that in the place to which he may be going there may be local ordinances to which he must accommodate himself and be governed thereby. This is a clause that would tend to keep him out of trouble.

The President:—There are restrictions in certain localities with regard to prohibition in having certain quantities of gasoline on hand. He should know of such ordinances.

Mr. Steffens:—A contractor on work in a locality apparently far removed from a town may disobey some local law, intentionally, or otherwise (as for example Sunday work), and become very fully aware of the fact upon the appearance of the Sheriff.

Mr. Earle:—I would like to ask if it is the sense of the Committee that the contractor shall be responsible for any injury to passengers of the railroad company, when, through the negligence of the railroad company, they go through a bridge or false-work which the contractor has in place.

Mr. Cartlidge:—Nothing that the Committee may do or say in these specifications will affect the responsibility for an accident caused by negligence, per se. The law is clear as to where the responsibility shall be placed. The railroad company is necessarily responsible to the public under the law.

The Secretary:—"21. Insurance. The contractor shall carry such liability insurance as is necessary to protect himself and the Railroad Company against loss or damage caused by injuries to his men, and shall furnish the Railroad Company a bond in form and of a surety acceptable to the Railroad Company, providing for the faithful performance of the work and all matters pertaining thereto, in such sum as shall be specified in the contract."

Mr. Earle:—We have had advice that the contractor can, if he wishes to, insure the Railroad Company, and the execution of this specification, if made a part of the contract, might in certain courts be so construed that the contractor would insure the railroad company.

Mr. Cartlidge:—That is the intention, to make an insurance clause out of this. Clause 21 says the contractor shall carry such liability insurance as is necessary to protect himself against loss or damage caused by injuries to his men, etc.

Mr. C. E. Smith:—We have been informed by our legal department that it is satisfactory for some contractors for erection to do their work without carrying liability insurance. We have recently finished up a contract for erection in which the contractor did not carry liability insurance. The matter was taken up with the legal department, and they in turn took it up with the bonding company. The bonding company stated it would be their loss if there were any. They investigate the financial standing of the erection company. If they were not satisfied that the erection company was financially sound to carry their own liability, they would not issue a bond. I suggest that the Committee consider that statement.

Prof. Walter Loring Webb (Consulting Engineer):—There is no use in putting in the specifications a clause which will not stand in the courts. It is perfectly conceivable that a railroad company might make changes, which they might excuse on the ground of greater safety, which would actually make increased cost to the contractor. Now, in a case of that kind, the court would unquestionably allow the contractor damages, and there is no use in putting in a clause saying that the contractor must stand the loss, because a court would not sustain such a specification.

The Secretary:—"22. ENGINEER. The term "Engineer," as used herein, shall be understood to mean the Chief Engineer of the Railroad Company, or his properly accredited representative."

Mr. McNab:—I would ask the Committee what they consider the difference is between the accredited representative of the Chief Engineer and the properly accredited representative of the Chief Engineer?

The President:—The Committee is willing to have the word "properly" eliminated.

The question is on the adoption of the specifications for publication in the Manual.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—In view of the fact that many of the sections have been referred back to the Committee, I do not think that the specifications can go into the Manual.

Mr. Snow:—I move that the specifications be referred back to the Committee.

(The motion carried.)

The President:—The next subject, secondary stresses, is submitted as a matter of information.

Prof. Henry S. Jacoby (Cornell University:—I desire to offer the following, which has a bearing on the work of this Committee:

I wish to call the attention of the Association to the desirability of making available the lessons regarding design and construction which may be obtained from the regular inspection of bridges in actual service, and to inquire whether it would not be wise to have this topic studied by the Committee on Iron and Steel Structures.

Perhaps the Committee has this subject under consideration at present, since it may properly be included under the fifth topic in the outline of work, which reads: "Influence of theory, experiment and experience on bridge design."

In connection with steel bridges there is hardly any material available in published form relating to the lessons taught by the observation of bridges under traffic conditions. All over the country bridge inspectors are making their rounds, looking at the details of bridges, and making records of conditions discovered and recommendations as to repairs required. After the repairs are made the incident is closed for that structure, and so the matter goes on year after year. There must inevitably be some important lessons taught by the extensive experience of these inspectors, which should influence design much more largely than it apparently does. One reason is that the maintenance department is entirely separate from the bridge department, in which the designs of new structures are developed. There are doubtless also other influences at work. Designers and draftsmen have but little opportunity to become familiar with these matters by direct observation. It seems that each railway does not get the full benefit of the experience of the maintenance department, thus leading to the continued construction of some faulty details because the designers do not learn, except incidentally, of the actual behavior of bridges previously designed by them.

For example, certain designs of bracketes on end floor beams perform their duty in an excellent manner under heavy modern live loads and the conditions of adjacent track, while others show marked defects; yet the defective designs are built over and over again on the roads in which the maintenance of way department has discovered their weakness.

This condition is not confined to steel bridges. I am convinced that some railways are losing at least two or three years of service in their Howe trusses because of the lesser relative efficiency of the splices in the lower chords. This is an indication that there are details in timber framing which are not receiving sufficient study by designers, although similar timber structures have been used for many years. This is probably true because the conditions under which failure occurs are not brought to the attention of designers.

The President:—If there is no further discussion, the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE XIII.—ON WATER SERVICE.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee submits herewith a report of its proceedings and work accomplished during the past year. Meetings were held as follows:

1. At Chicago, May 17, 1910.—Members present: Robert Ferriday. J. L. Campbell, A. Mordecai, L. P. Rossiter, H. M. Church and W. A. Parker.

2. At Chicago, June 22, 1910.—Members present: C. L. Ransom, J. L. Campbell, H. M. Church, G. H. Herrold, F. G. Hoskins (representing E. G. Lane), W. A. Parker.

3. At Chicago, July 29, 1910.—Members present: C. L. Ransom, Robert Ferriday and F. G. Hoskins (representing E. G. Lane).

4. At Chicago, October 5, 1910.—Members present: C. L. Ransom, Robert Ferriday, H. M. Church, G. H. Herrold, E. G. Lane, W. A. Parker and F. G. Hoskins with Mr. Lane.

The following sub-committees were appointed and their reports and conclusions are hereto appended:

Sub-Committee "A," to consider subject, "Revision of the Manual:"
Robert Ferriday, Chairman;
A. D. Schermerhorn.

Sub-Committee "B," to consider subject, "Water Tank Specifications:"
J. L. Campbell, Chairman;
G. H. Herrold,
W. A. Parker,
C. A. Morse.

Sub-Committee "C," to consider subject, "Water Stations for Track Pans:"
E. G. Lane, Chairman;
L. P. Rossiter,
H. M. Church,
James Burke,
A. Mordecai.

Sub-Committee "D," to consider subject, "Recommendations for Next Year's Work:"
C. L. Ransom, Chairman;
Robert Ferriday,
J. L. Campbell,
E. G. Lane.

REVISION OF THE MANUAL.

This work has been done in the proof as per report on pp. 1143 and 1144, Vol. 11, Part 2, and no further suggestions are made at this time.

WATER TANK SPECIFICATIONS.

It was decided at the first meeting of the General Committee that an attempt would be made to present for approval only specifications and designs for two styles of tanks: These to be the *Wooden Tub* on *Wooden Substructure,* and the *Metal Stand Pipe Tank.*

The reinforced concrete tank was considered as rather a new departure, and it was therefore decided to submit the following specifications and design as a progress report only:

SUGGESTED SPECIFICATIONS FOR A REINFORCED CONCRETE WATER TANK.

Kind.

1. The tank shall be of reinforced concrete, as shown on the drawings.

Capacity.

2. The capacity of the tank shall be within the limits of 50,000 and 106,000 gallons, exclusive of the lower 20 ft. of the tank. The height of the tank from bottom to top of shell shall be 40 ft. A diameter of 30 ft. is recommended. On this basis the drawings have been made. The latter shall be made to meet the requirements of the height and diameter selected by the engineer.

Location.

3. The tank is designed to deliver water to locomotives through water columns. The floor of the tank shall not be lower than the tracks served.

Excavations.

4. In earth, the excavations for the foundation and pipes shall be as deep as the lowest frost line, with a minimum depth of four ft. In rock, only the trenches for the pipes shall be carried below the action of frost. In earth, the bottom of excavations shall be thoroughly tamped to discover and compact any soft places. If the earth will not sustain the total load, including wind pressure, without material or unequal settlement, the foundation shall be supported on piles of the number, size and arrangement as determined by the engineer. Such piles shall conform to the specifications of this Association for piling, as selected by the engineer.

Foundation.

5. The foundation shall consist of a disk of concrete, as shown. If the depth of frost is excessive, this disk may be carried on broken rock compacted in the bottom of the excavation, but the minimum vertical thickness of the concrete foundation, exclusive of the tank floor, shall be 42 in.

Valve Box.

6. The valve box for the piping shall be constructed as a part of the foundation, as shown. The top and bottom of the box shall be reinforced by steel rods laid both ways and doubled around the pipes and the man-

hole. The manhole frame shall be in one piece of first-class cast-iron with a double seat and a double cover. The latter shall preferably be of wood. When low temperatures require to prevent freezing within the valve box, an air space shall be constructed in the middle of that portion of the box walls outside of the tank foundation. When the absence of low temperatures permit, the air space and the lower manhole cover may be omitted.

Floor.

7. The reinforced concrete floor on the foundation shall be constructed, as shown, giving its surface a sidewalk finish without plastering.

Shell.

8. The reinforced concrete shell shall be constructed, as shown, building in the concrete fillet in the angle at the bottom.

Roof.

9. The reinforced concrete roof, including manhole and cover, shall be constructed, as shown, finishing top of roof as specified for the floor. Where ice will not form to an injurious or troublesome extent and sunlight will not cause vegetable growth in the water, this roof may be omitted at the discretion of the engineer.

Piping.

10. The tank shall be equipped with cast-iron piping and standard gate valves, as shown. There shall be a tank supply pipe, a water column supply pipe, an overflow pipe and a washout pipe, the latter two being combined in the valve box beyond the valve closing the washout pipe. There shall be no valve in the overflow pipe. For a gravity supply, the tank supply pipe shall be carried to the top of the tank and be capped by a float valve. The washout pipe shall terminate flush with the tank bottom. The water column pipe shall extend several feet above the bottom but not higher than the top of the water column. All piping shall pass through the bottom of the tank, preferably in cast-iron stuffing boxes with lead joints, as shown, but other forms of stuffing box and joint may be used.

All pipes and castings, in quality, manufacture and inspection, shall fulfill the requirements of the specifications of the New England Water Works Association for cast-iron pipe.

The weights and diameters of the pipes shall be determined by the engineer. No pipe shall have an inside diameter less than 4 in.

Sludge pipe.

11. The cast-iron sludge pipe shall be carefully constructed, enclosing in the concrete and doubling the reinforcing rods around it, as shown. When absence of sediment in the water justifies, this pipe may be omitted.

Gage.

12. The tank shall be equipped with a gage, indicator and float, according to the design or selection of the engineer.

Ladder.

13. The steel ladder shall be constructed, as shown and as designed, or selected by the engineer. The ladder shall be carried by connecting straps or angles resting on the roof. It shall not be anchored to the tank shell. The steel shall conform to the specifications of this Association for steel bridges.

Concrete.

14. The concrete in the tank foundation and the side walls of the valve box shall be a 1-3-5 mix, made and laid in accordance with the specifications of this Association for Portland Cement Concrete.

Reinforced concrete.

15. The top and the bottom of the valve box and the tank floor, shell and roof shall be made of reinforced concrete.

Mixture.

16. Reinforced concrete shall be a thoroughly uniform mixture of cement, sand, stone and water completely enveloping the reinforcing rods.

Proportions.

17. The volume of the sand shall be 5 per cent. in excess of the volume of the voids in the stone. The volume of the cement, considering 100 lbs. of it as 1 cu. ft., shall be 25 per cent. in excess of the volume of the voids in the mixed sand and stone. The engineer shall determine the voids and proportions.

Fluidity.

18. The volume of the water shall be sufficient to give the concrete a fluidity that will cause it to flow and mould itself in the forms without tamping.

Mixing.

19. The concrete shall preferably be mixed by mixing machines. The method used shall yield a complete and even mixture.

Cleanliness.

20. All dirt and foreign matter shall be excluded from all materials, concrete and stages of the work.

Pouring and working.

21. The concrete, after mixing, shall be poured and worked into final position in the forms before its initial set is complete, and it shall not thereafter be disturbed. As it is thus placed, it shall be thoroughly worked by long, flat, thin-bladed tools in a manner that will eliminate all voids and air pockets and produce unbroken mortar faces against all forms and secure perfect contact with every part of all reinforcing rods.

Joints.

22. The surface of concrete shall be clean and wet when concrete is laid thereon. The surface, if hardened, shall also be mopped with cement grout immediately in advance of placing fresh concrete. Smooth or finished mortar surfaces shall be avoided where additional concrete is to be placed. If necessary, as in the joints between the tank floor, shell

and fillet, old surfaces shall be tooled, cleaned and grouted before concrete is placed thereon.

Wetting.

23. A rapid drying out of concrete shall be prevented by regular, frequent and continued wetting until all danger of arrested setting and hardening is past, as the engineer shall direct.

Freezing.

24. Freezing of concrete before it has finally set shall be prevented.

Broken.

25. Any concrete broken or displaced in any manner after having set shall be removed from the work.

Cement.

26. The cement shall conform to the specifications of this Association for Portland Cement. It shall retain its original purity and qualities until it is incorporated into the work. Deteriorated or otherwise damaged cement shall not be used.

Sand.

27. The sand shall be clean, sound and sharp and it shall be of graded sized grains giving a minimum of voids.

Stone.

28. The stone shall be clean, sound and durable. The word "stone" includes broken rock and gravel. The stone shall be of graded sizes giving a minimum of voids. All of it shall be able to pass through a circular hole having a diameter of ¾ in.

Water.

29. The water shall be clean and free from anything injurious to the concrete.

Forms.

30. The concrete forms shall be made of metal or of dressed and matched lumber. They shall be accurately made and erected, be water tight, and shall have ample strength and rigidity to prevent bending and warping under the load and action of the concrete. They shall be erected in such sections and courses as will permit the concrete to be poured and worked as above specified. No device for holding the forms that would leave a hole through the concrete shall be used. Wires passing through the concrete shall be nipped off beneath the concrete face.

Pointing.

31. Any break in the concrete surfaces not impairing the integrity of the structure shall be pointed with cement mortar, as the engineer shall direct. Any other imperfections in the concrete shall be treated and remedied as the engineer shall direct.

Reinforcement.

32. The concrete shall be reinforced by steel rods of the form, size, number and arrangement, as shown. They shall be wired at intersections with each other and be maintained in required position as they are buried

in the concrete, at which time they shall be free from dirt and scale. Splices in rods shall be lapped 42 diameters or sides. No splice shall be opposite a splice in an adjacent line of rods. Throughout the splice the ends of the rods making it shall be 1½ diameters or sides apart in the clear. There shall be not more than four splices in the circumference of a tank 30 ft. in diameter. Unnecessary splicing shall be avoided.

Reinforcing rods.

33. The reinforcing rods shall be plain or deformed. Their tensile strength per sq. in. shall be between 60,000 and 90,000 lbs. Their elastic limit shall be not less than ½ of their tensile strength. They shall not be stressed more than one-third of their elastic limit. Any rod shall be capable of being bent cold on a radius of three diameters or sides through 180 degrees without sign of fracture.

Waterproofing.

34. A dense, even mixture of concrete as herein specified for reinforced concrete shall be the primary expedient to secure water-tight concrete. This may be supplemented by mixing with the cement some form of waterproofing compound of proved efficiency and now obtainable from manufacturers.

Where the concrete can be worked before it has set, the surface shall be thoroughly troweled until a dense mortar face is secured. Concrete surfaces already set may be plastered by rich cement mortar, but surfaces so treated shall first be cleaned and roughened by steel brushes or equivalent, and the plastering shall be applied on a fresh coat of cement grout mopped on the surface.

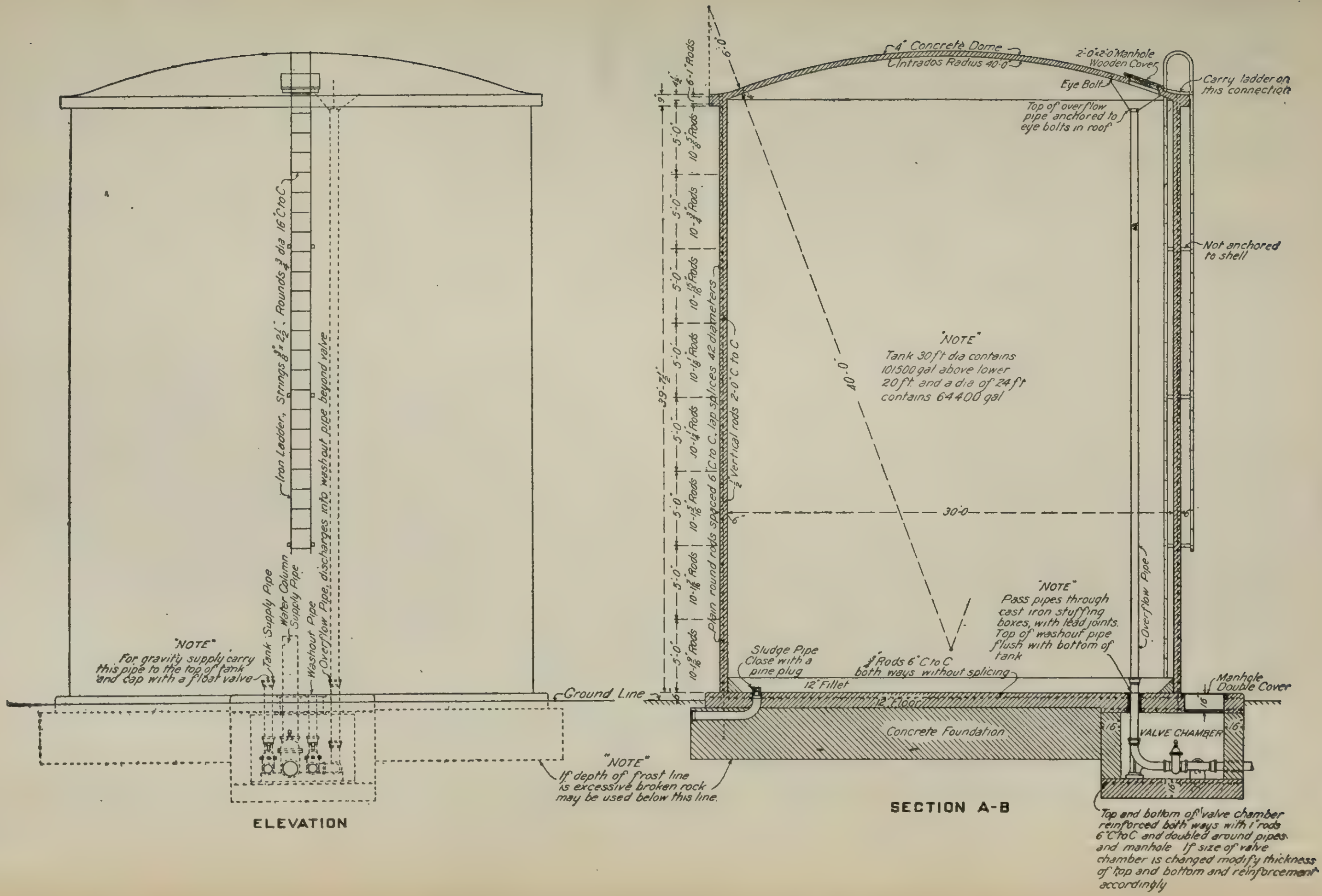
In addition, if necessary, separate and alternate washes of soap and alum in the order named shall be applied to the dried and hardened concrete surface. The number of washes should be not less than two of each, with a 24-hour interval between each. The proportions should be approximately ¾ lb. of soap and ⅛ lb. of alum per gallon of water. These proportions may be varied if better results are thereby secured. The soap wash shall be applied boiling hot, without causing frothing. The alum wash should have a temperature between 60 and 80 degrees Fahrenheit.

In lieu of these washes approximately 1 per cent., by weight, of powdered alum may be evenly mixed with the cement, in which case the same proportion of soap shall be dissolved in the water in making the concrete.

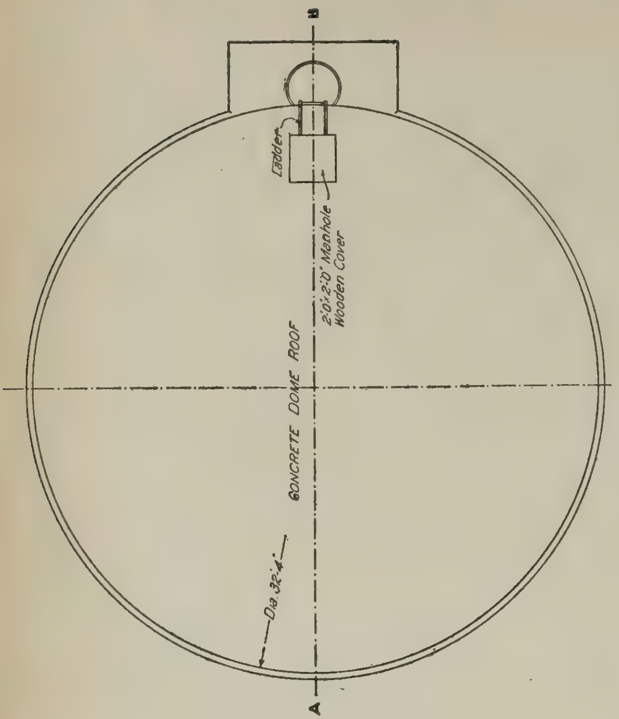
In lieu of soap and alum, waterproofing paint having an asphalt base to be applied hot or cold, and now obtainable from manufacturers, may be used. In all washing or painting the concrete surface treated shall be dry and clean and the temperature should be above the freezing point.

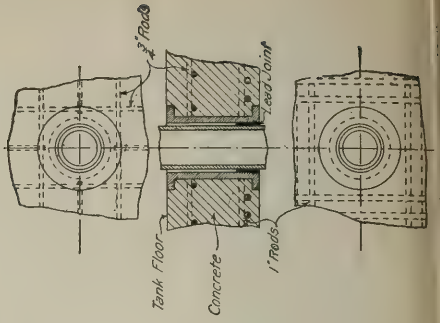
Loading.

35. The weight of water shall be assumed to be 63 lbs. per cu. ft. Wind pressure, acting in any direction, shall be assumed to be, in pounds, thirty times the product of the height by two-thirds of the diameter of the tank, in feet.

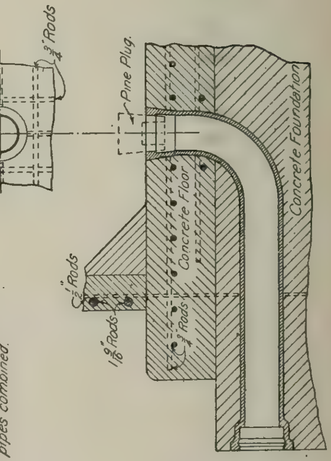

"NOTE"
For gravity supply carry this pipe to the top of tank and cap with a float valve
Tank Supply Pipe
Water Column Supply Pipe
Washout Pipe
Overflow Pipe, discharges into washout pipe beyond valve
Iron Ladder, Strings 3/8"×2½", Rounds ¾" dia 16" C to C
Ground Line
"NOTE"
If depth of frost line is excessive broken rock may be used below this line.
ELEVATION
4" Concrete Dome
Intrados Radius 40'-0"
2'-0"×2'-0" Manhole Wooden Cover
Eye Bolt
Carry ladder on this connection
Top of overflow pipe anchored to eye bolts in roof
Not anchored to shell
6'-0"
6-1" Rods
10-5/8" Rods
10-3/4" Rods
10-15/16" Rods
10-1⅛" Rods
10-1¼" Rods
10-1 5/16" Rods
10-1 7/16" Rods
10-1 9/16" Rods
5'-0"
9"
4½"
39'-7½"
Plain round rods spaced 6" C to C, lap splices 42 diameters
½" Vertical rods 2'-0" C to C
6"
40'-0"
30'-0"
"NOTE"
Tank 30 ft dia contains 101500 gal above lower 20 ft. and a dia of 24 ft contains 64400 gal
"NOTE"
Pass pipes through cast iron stuffing boxes, with lead joints. Top of washout pipe flush with bottom of tank
Overflow Pipe
Sludge Pipe Close with a pine plug
12" Fillet
¾" Rods 6" C to C both ways without splicing
12" Floor
Concrete Foundation
Manhole Double Cover
VALVE CHAMBER
16"
Top and bottom of valve chamber reinforced both ways with 1" rods 6" C to C and doubled around pipes and manhole. If size of valve chamber is changed modify thickness of top and bottom and reinforcement accordingly
SECTION A-B

REINFORCED CONCRETE WATER TANK.

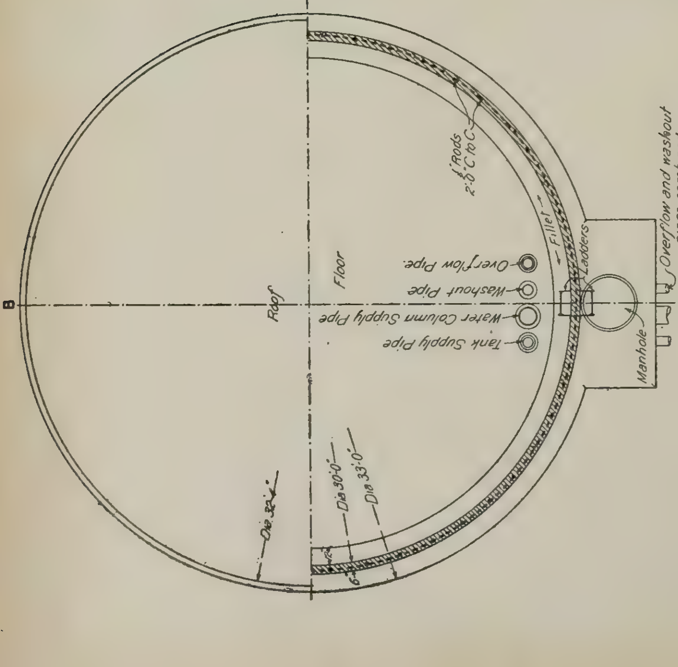




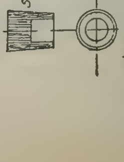
ROOF PLAN



DETAIL OF SLUDGE PIPE.



PLAN



DETAIL OF PLUG FOR SLUDGE PIPE.

Definitions.

36. The words "company," "engineer," "drawings," "as shown," and "this Association" appearing in these specifications are defined as follows:

"Company" means the railway company building a tank under these specifications.

"Engineer" means the engineer of the company.

"Drawings" means the drawings of the tank herein specified and forming a part of these specifications, including such working drawings as the engineer shall prepare or approve.

"As shown" means as shown on the drawings.

"This Association" means the American Railway Engineering and Maintenance of Way Association.

SPECIFICATIONS FOR WOODEN WATER TANK.

Kind.

1. The tank shall be a wooden tub carried on timber posts supported on concrete piers, as shown on the drawings. These specifications provide for an all-wood structure above the foundation, as shown.

Capacity.

2. A diameter of 24 ft. and a height of 16 ft. (outside measurement) are recommended for the tub of this tank. Other dimensions may be used, but the design shall conform to the requirements of these specifications.

Location.

3. The tank is designed to deliver water to locomotives through water columns. The bottom of the tub shall be not less than 20 ft. above the tracks served.

If water columns are not used, the location of the tank and the necessary tank fixtures shall be as selected by the company.

Loading.

4. Water shall be assumed to weigh 63 lbs. per cu. ft. Wind pressure in pounds acting in any direction on the tub shall be assumed to be thirty times the product of the height by two-thirds of the diameter of the tub. The wind pressure on the substructure shall be assumed at 30 lbs. per sq. ft. of its surface acted on.

Anchorage.

*5. Necessary anchorage shall be provided to the foundation on the basis of an empty tub, as the engineer shall design and require.

Foundation.

6. In earth, the excavation for the piers and frost pit shall be deep enough to permit the pipes to be laid below the frost line, with a minimum depth of 4 ft. In rock, only the excavations for the frost pit and the pipe trenches shall be carried below the action of frost.

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*See amendments, page 347.

On earth, the total load including wind stress shall not exceed the safe load for that earth. If the earth will not carry this load without material settlement, piling shall be put in as the engineer shall direct. Such piling shall conform to the specifications of this Association for piling, as selected by the engineer. Earth foundations shall be thoroughly tamped to detect and compact any soft places therein.

Piers and frost pit.

*7. The piers and frost pit shall be of concrete of a 1-3-5 mix, made and laid according to the specifications of this Association for Portland Cement Concrete and to the forms and dimensions, as shown, including the proper setting of all anchor bolts.

Substructure.

8. The substructure shall be constructed, as shown. The timber shall be pine, oak, cypress or redwood, S 4 S for painting, and conforming to the specifications of this Association for No. 1 R. R. bridge timber. It shall be accurately framed and erected, properly tightening all bolts and tie rods.

Rods and bolts.

9. All rods and bolts shall be iron or steel of the quality hereinafter specified for tank hoops. O. G. washers shall be used under heads and nuts of bolts and tie rods.

Tub: quality of lumber.

*10. The tub shall be made of pine, cypress or redwood, sound, seasoned, out of wind, free from shakes, sap, pitch pockets or streaks, unsound knots, loose knots, knots in clusters, and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged. Material having knots in its edges will not be accepted.

Tub bottom.

*11. The bottom of the tub shall be made of 3-in. planks, S 4 S, and accurately cut and planed to uniform thickness and width. The ends shall be cut to the true circle of and shall fill the croze in the staves. Each plank shall be in one piece without joint or splice. The planks shall be joined by ¾-in. by 3-in. wood dowels on 30-in. centers along each joint. The bottom shall be laid directly on the floor joists.

Tub staves.

*12. The staves shall be of uniform width, end to end, and shall be made of 3-in. planks, S 4 S, with edges accurately planed on radial lines from center of tub. Each stave shall be in one piece, without joints or splice. The croze in each stave shall be accurately cut to uniform dimensions on one circle for all staves. The croze shall be 3 in. in the clear from the end of the stave.

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*See amendments, page 347.

Tub hoops.

*13. The tub hoops shall be half oval, half round, or round. They shall preferably be made of wrought-iron. They may be made of steel.

Wrought-iron shall be made of pure puddled iron having a tensile strength of 50,000 lbs. and containing of

Sulphur	not more than	.02	per cent.
Phosphorus	" " "	.005	"
Carbon	" " "	.02	"
Manganese	" " "	.00	"
Silicon	" " "	.00	"

Steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

Each hoop shall be in three equal sections.

Hoop coating.

*14. Each hoop shall be cleaned (preferably at the factory) of dirt, rust and scale, and in that condition shall be heated to 300 degrees Fahrenheit and be dipped in pure asphalt having that temperature which shall be maintained during the immersion which shall continue not less than one minute.

Hoop joints.

*15. Hoops shall have round threaded ends passing through lugs. The joint used shall be as designed or selected by the engineer. It shall be as strong as the hoop.

Hoop spacing.

16. Hoops shall be of one size with the spacing varied, limiting the maximum space to 24 in. c. to c. of hoops.

Hoop stresses.

*17. Hoops shall be so spaced that, for wrought-iron, the stress per sq. in. on net section shall not exceed 10,000 lbs., and for steel 12,000 lbs. Threaded hoops shall preferably have upset ends, but a larger hoop giving the required area under thread without upsetting may be used.

Roof.

*18. The roof shall preferably be built in the form of a flat dome, as shown, but other forms may be used.

Roof joists.

19. Each joist of the dome form shall preferably be in one piece of full-sized 2-in. lumber, but the longer joists may be built up to an equivalent section. The top of each joist shall be cut to a template having a radius of 84.5 ft., each end of the joist having a depth of 4 in. The length of each joist is determined by its position within the circle having a diameter of 25 ft. 6 in. and cutting the ends of the joists, as shown.

Roof sheathing.

20. On the roof joists, 1-in. by 6-in. sheathing shall be laid solid and shall be cut to a circle having a diameter of 26 ft., as shown.

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*See amendments, page 347.

Roof eave.

21. The roof eave shall be finished by 1-in. lumber and quarter rounds built on the ends of the joists, as shown.

Roofing.

22. The sheathing shall be covered by metal, bituminous felt or burlap roofing, tar and gravel, asphalt mastic, or other prepared waterproof roofing, limiting the selection to brands of proved efficiency. If other than the dome form of roofing is used, shingles or barn boards may be used.

Manhole.

23. The manhole in the roof shall be constructed as shown.

Frostproof floor.

24. When required for frostproofing the roof shall be oiled, as shown. Where ice will not form to an injurious or troublesome degree and sunlight will not cause vegetable growth in the water, the entire roof and ceiling may be omitted.

Frost shaft.

25. The frost shaft, extending from the frost pit to the bottom of the tub, shall be constructed, as shown, enclosing it by multiple walls of 1-in. by 6-in. lumber, S 1 S and 2 E, separated by 2-in. by 4-in. studding on edge or side. Each wall shall have two courses of lumber separated by a layer of heavy tar felt. The outside course shall be tongued and grooved. The number of walls shall be sufficient to prevent water in the enclosed pipe from freezing. A frostproof door in one side of the shaft shall be constructed as designed by the engineer.

Where ice will not form, the entire frostproofing, including pit, may be omitted.

Lumber.

26. All lumber in the roof and frostproofing shall be No. 1 common, as rated by the Lumbermen's Association for the district supplying the material.

Piping.

27. The tank shall be equipped with a tank supply pipe, a water-column supply pipe and an overflow pipe, as shown. The first two shall be provided with gate valves. For a gravity supply the tank supply pipe shall be carried to the top of the tank and capped by a float valve. The sizes of the pipe shall be determined by the engineer. No pipe shall have an inside diameter less than 4 in. All pipes shall pass through the bottom of the tank by two standard flanges full bolted with gaskets. For a pressure gravity supply, a stuffing box in lieu of flanges for the tank supply pipe may be used if necessary to prevent leakage. All pipes shall be enclosed in the frost shaft and pit and leave the latter below the frost line.

Sludge hole.

28. In the bottom of the tank outside of the frost shaft a sludge hole with plug shall be constructed as designed or selected by the engineer.

Water tightness.

29. When the tank is finished, the hoops properly tightened and the wood saturated, the tub shall be water tight. No foreign material shall be used in making the joints in the tub.

Gage.

30. The tank shall be equipped with a gage, indicator and float as designed or selected by the engineer. The clearance between the gage board and the tub shall not be less than 1 in.

Ladders.

31. The ladders shall be constructed, as shown, and as designed, or selected by the engineer.

Painting.

32. All exposed woodwork shall be painted with one priming and two finishing coats, using the company's standard paint and colors for such work. All wood to be painted shall be dressed.

Definitions.

33. The words "company," "engineer," "as shown," "drawings" and "this Association" appearing in these specifications are defined as follows:

"Company" means the railway company building a tank under these specifications.

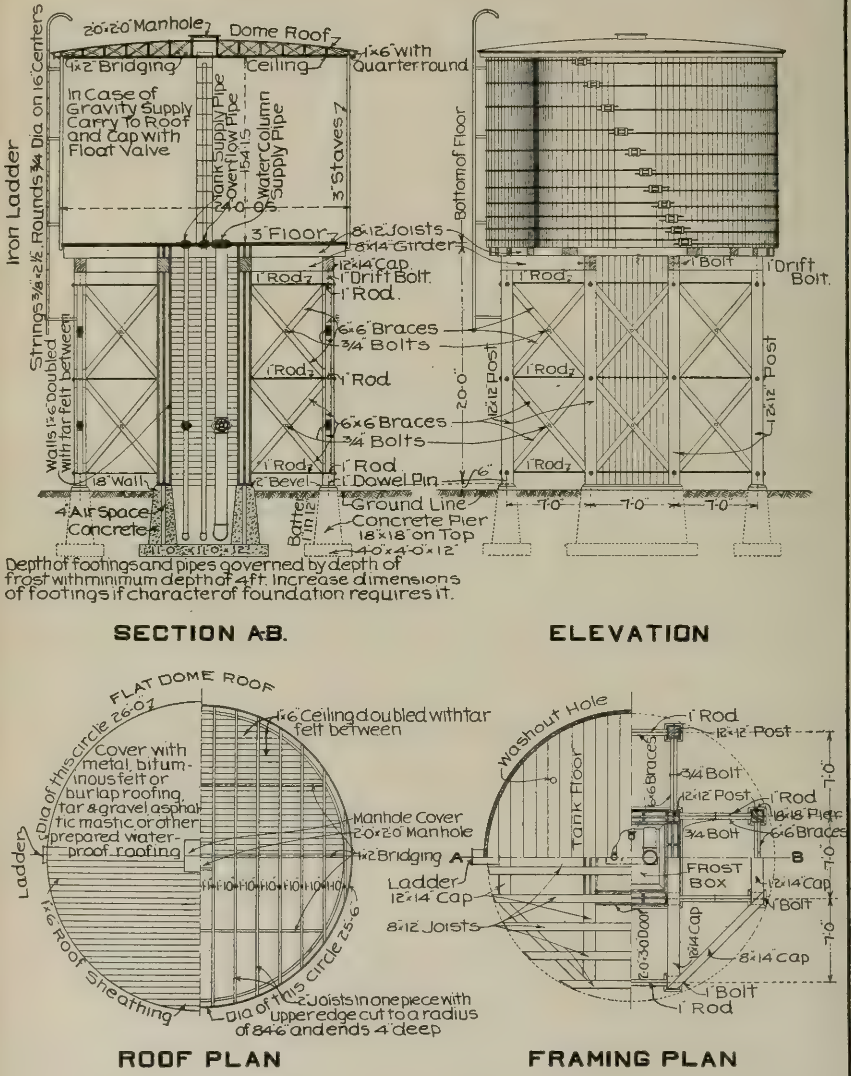
"Engineer" means the engineer of the company.

"Drawings" means the drawings of the tank herein specified and forming a part of these specifications, including such working drawings as the engineer shall prepare or approve.

"As shown" means as shown on the drawings.

"This Association" means the American Railway Engineering and Maintenance of Way Association.

WOODEN WATER TANK
WATER SERVICE
1910-1911



AMENDMENTS.

Amend the Specifications for Wooden Water Tanks in the following particulars:

Clause 5 to read: "Anchorage. Necessary anchorage to the foundation shall be provided."

Clause 7 to read: "Piers and frost pit. The piers and frost pit shall be of masonry, to be laid according to the specifications of this Association and to the forms and dimensions, as shown, including the proper setting of all anchor bolts."

Clause 10. Change first line to read: "Tub shall be made of suitable pine," etc. Omit comma after the word "small," in the fourth line. Provide for the use of cedar for staves and fir for the bottom of tub.

Clause 11 to read: "Tub bottom. The bottom of the tub shall be made of 3-in. planks, S 4 S, and accurately cut and planed to uniform thickness and width. The ends shall be cut to the true circle of and shall fill the croze in the staves. Each plank shall be in one piece, without joint or splice, for all tanks having a diameter not greater than 24 ft. The planks shall be joined by ¾-in. by 3-in. wood dowels on 30-in. centers along each joint. The bottom shall be laid directly on the floor joists."

Clause 12: Change the word "the" in the first line to "each," and make the word "staves" singular.

Clause 13. Change first and last paragraphs of the clause to read: "Each hoop shall be in not more than three sections, half oval, half round or round."

Clause 14. Add the following to the last sentence: "Or the application of such other coating as the engineer shall approve."

Clause 15 to read: "Round hoops shall have round threaded ends, passing through lugs. The joints used for round hoops and all others shall be as designed or selected by the engineer."

Clause 17: Omit the last two lines of the clause.

Clause 18: Change the word "shall" in the first line to "may." Omit the word "preferably."

Change clauses 19, 20, 21, 22 and 23 to conform to the change in clause 18.

Transpose the definitions given in clause 33 to clause 1, and renumber succeeding clauses.

GENERAL SPECIFICATIONS FOR ORDINARY IRON OR STEEL WATER AND OIL TANKS.

Ordinary tanks defined.

1. Ordinary tanks are those requiring plates not more than ⅝-in. thick.

Scope of specifications.

2. These specifications cover ordinary iron or steel tanks commonly used by railways for usual service conditions only.

Quality of metal.

3. The metal in these tanks shall be wrought-iron or open-hearth steel.

The iron shall be manufactured from pure puddled iron having a tensile strength of 50,000 lbs. per sq. in. This iron shall contain of

Sulphur	not more than	.02	per cent.
Phosphorus	" " "	.005	"
Carbon	" " "	.02	"
Manganese	" " "	.00	"
Silicon	" " "	.00	"

The steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

For plates not more than ⅜-in. thick, ⅝-in. rivets shall be used. For thicker plates the diameter shall be ¾-in.

Loading.

4. The weight of water shall be assumed to be 63 lbs., crude oil 56 lbs., and creosote 66 lbs. per cu. ft. Wind pressure, acting in any direction, shall be assumed to be, in pounds, thirty times the product of the height by two- thirds of the diameter of the tank in feet.

Unit stresses.

5. Unit stress shall not exceed the following:

For Iron:

(a) Tension in plates, 10,000 lbs. per sq. in. on net section.
(b) Shear in plates, 8,500 lbs. per sq. in.
(c) Shear on rivets, 10,000 lbs. per sq. in.
(d) Bearing pressure on field rivets, 18,000 lbs. per sq. in.

For Steel:

(a) Tension in plates, 12,000 lbs. per sq. in. on net section.
(b) Shear in plates, 10,000 lbs. per sq. in.
(c) Shear on rivets, 10,000 lbs. per sq. in.
(d) Bearing pressure on field rivets, 18,000 lbs. per sq. in.

Cylindrical rings.

6. Plates forming the shell of the tank shall be cylindrical and of different diameters, in and out, from course to course.

Workmanship.

7. All workmanship shall be first-class. All plates shall be beveled on all edges for caulking after being punched. The punching shall be

from the surface to be in contact. The plates shall be formed cold to exact form after punching and beveling. All rivet holes shall be accurately spaced. Drift pins shall be used only for bringing the parts together. They shall not be driven with enough force to deform the metal about the holes. Power riveting and caulking should be used. A heavy yoke or pneumatic bucker shall be used for power-driven rivets. Riveting shall draw the joints to full and tight bearing.

Caulking.

8. The tank shall be made water tight by caulking only. No foreign substance shall be used in the joints. For water tanks, the caulking shall preferably be done on the inside of tank and joint only; but for oil tanks the caulking should be done on both sides. No form of caulking tool or work that injures the abutting plate shall be used.

Minimum thickness of plates.

9. The minimum thickness of plates in the cylindrical part of tank shall not be less than ¼-in. and in flat bottoms not less than 5/16-in. In curved bottoms the thickness of plate shall be not less than that of the lower plate in the cylindrical part.

Horizontal and radial joints.

10. Lap joints shall generally be used for horizontal seams and splices and for radial seams in curved bottoms.

Vertical joints.

11. For vertical seams and splices, lap joints shall be used with plates not more than ⅜-in. thick. With thicker plates, double butt joints with inside and outside straps shall generally be used. The edge of the plate in contact at the intersection of horizontal and vertical lap joints shall be drawn out to a uniform taper and thin edge.

Rivet holes, punching and pitch.

12. The diameter of rivet holes shall be 1/16-in. larger than the diameter of the rivets used. The punching shall conform to the specifications of this Association for such work on steel bridges. A close pitch, with due regard for thickness of plate and balanced stress between tension on plates and shear on rivets, is desirable for caulking.

Tank support.

13. If the tank is supported on iron or steel columns with bracing, the metal in such substructure shall conform to these specifications, and the anchorage and workmanship thereof shall conform to the specifications of this Association for the manufacture and erection of steel bridges.

Painting.

14. After being completely erected, caulked and cleaned of dirt, rust and scale, all exposed metal work shall be painted or treated with such coat or coats of paint or metal preservative as shall be selected by the railway company.

Plans and specifications.

15. Under these specifications and in conformity thereto the railway company shall cause to be prepared or shall approve detailed plans and

specifications for such tanks, herein specified, as it shall construct. Such plans and specifications shall cover all necessary tank auxiliaries.

SPECIFICATIONS FOR AN IRON OR STEEL WATER TANK.

Kind.

1. The tank shall be of iron or steel on a foundation, as shown on the drawings.

Capacity.

2. The capacity of the tank should be within the limits of 50,000 and 100,000 gallons, exclusive of the lower 20 ft. of the tank. The height of the tank from bottom to top of shell should be within 12 in. of 40 ft. A diameter of 30 ft. is recommended. On this basis the drawings have been made. The latter shall be made to meet the requirements of the height and diameter selected by the engineer.

Location.

3. The tank is designed to deliver water to locomotives through water columns. The floor of the tank shall not be lower than the tracks served. If water columns are not used, the location of the tank and the necessary tank fixtures shall be such as shall be selected by the company.

Excavation.

4. In earth, the excavations for the concrete footings and the pipes shall be as deep as the lowest frost line, with a minimum depth of 4 ft. In rock, only the trenches for the pipes shall be carried below the action of frost. In earth, the bottom of the excavations shall be thoroughly tamped to discover and compact any soft places. If the earth will not sustain the total load, including wind pressure, without material or unequal settlement, the foundation shall be supported on piles of the number, size and arrangement as determined by the engineer. Such piles shall conform to the specifications of this Association for piling, as selected by the engineer.

Foundation.

5. The foundation shall consist of a ring of concrete under the shell of the tank enclosing a broken rock foundation, as shown. Under the broken rock the earth shall be excavated, back filled and tamped to such depth and in such manner as may be necessary to secure proper support.

Valve box.

6. The concrete valve box for the piping shall be constructed as a part of the foundation, as shown. The manhole frame through the top of the box shall be in one piece of first-class cast-iron with double seat and double cover. The latter shall preferably be of wood. When low temperatures require to prevent freezing within the box, an air space shall be constructed in the middle of that portion of the box walls outside of the tank foundation. When the absence of low temperatures permit, the air space and the lower manhole cover may be omitted.

Anchor bolts.

7. When wind pressure requires, the tank shall be anchored to the foundation by anchor bolts and lugs, as shown, and as designated or approved by the engineer.

Concrete.

8. The concrete in the foundation of the tank and the side walls of the valve box shall be a 1-3-5 mix, made and laid in accordance with the specifications of this Association for Portland Cement Concrete. In the top and bottom of the valve box the concrete shall be a 1-2-4 mix, made and laid in accordance with the specifications of this Association for reinforced Portland Cement Concrete. The extreme fiber stress on concrete shall not exceed 600 lbs., and in steel shall not exceed 12,000 lbs. per sq. in. as given by the straight line formula.

Reinforcing rods and anchor bolts.

9. These rods and bolts shall be of steel and in quality they shall fulfill the requirements of these specifications for the steel in this tank.

Piping.

10. The tank shall be equipped with cast-iron piping and standard gate valves, as shown. There shall be a tank supply pipe, a water-column supply pipe, an overflow pipe and a washout pipe, the latter two being combined in the valve box beyond the valve closing the washout pipe. There shall be no valve in the overflow pipe. For gravity supply the tank supply pipe shall be carried to the top of the tank and be capped by a float valve. The washout pipe shall terminate flush with the tank bottom. The water-column pipe shall extend several feet above the bottom but not higher than the top of the water column. All piping shall pass through the bottom of the tank, preferably in cast-iron stuffing boxes with lead joints, as shown, but other forms of stuffing box and joint may be used.

All pipes and castings in quality, manufacture and inspection shall fulfill the requirements of the specifications of the New England Water Works Association for cast-iron pipe.

The weights and diameters of the pipes shall be determined by the engineer. No pipe shall have an inside diameter less than 4 in.

Sludge hole.

11. A sludge hole shall be constructed in the side of the tank at the bottom, as shown, and as designed or approved by the engineer. This opening shall preferably have a reinforcing ring and a cover plate, as shown, but other forms, including cast-iron, may be used.

If the absence of sediment in the water justifies, this opening may be omitted.

Roof.

12. The tank roof shall be constructed of metal, including manhole, as shown. If necessary to prevent ice forming to an injurious or troublesome degree over the water in the tank, a ceiling shall be constructed under the roof of doubled 1-in. by 6-in. lumber, No. 1 common of the

Lumbermen's Association for the district supplying the material, with a layer of heavy tar felt between. This ceiling shall be nailed to 2-in. by 4-in. nailing strips, bolted to the top of I-beams carrying the ceiling. The latter shall be standard beams of proper weight and spacing for the span and load and shall be carried by the shell of the tank through standard connections.

Where ice will not form, as specified above, and sunlight will not cause vegetable growth in the water, the entire roof and ceiling may be omitted, in which event finish top of tank shell by a ⅜-in. by 3-in. by 3-in. angle.

Ladder.

13. The ladder shall be constructed, as shown, and as designed or selected by the engineer. The metal in this ladder, in quality and manufacture, shall fulfill the requirements of these specifications for the metal in the tank.

METAL SPECIFICATIONS.

Quality of metal.

14. The metal in the tank shall be wrought-iron or open-hearth steel.

The iron shall be manufactured from pure puddled iron having a tensile strength of 50,000 lbs. per sq. in. This iron shall contain of

Sulphur	not more	than		.02	per cent.
Phosphorus	"	"	"	.005	"
Carbon	"	"	"	.02	"
Manganese	"	"	"	.00	"
Silicon	"	"	"	.00	"

The steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

The rivets shall be ⅝-in. in diameter.

Loading.

15. The weight of water shall be assumed to be 63 lbs. per cu. ft. Wind pressure, acting in any direction, shall be assumed to be, in pounds, thirty times the product of the height by two-thirds of the diameter of the tank in feet.

Unit stresses.

16. Unit stresses shall not exceed the following:

For Iron:

- (a) Tension in plates, 10,000 lbs. per sq. in. on net section.
- (b) Shear in plates, 8,500 lbs. per sq. in.
- (c) Shear on rivets, 10,000 lbs. per sq. in.
- (d) Bearing pressure on field rivets, 18,000 lbs. per sq. in.

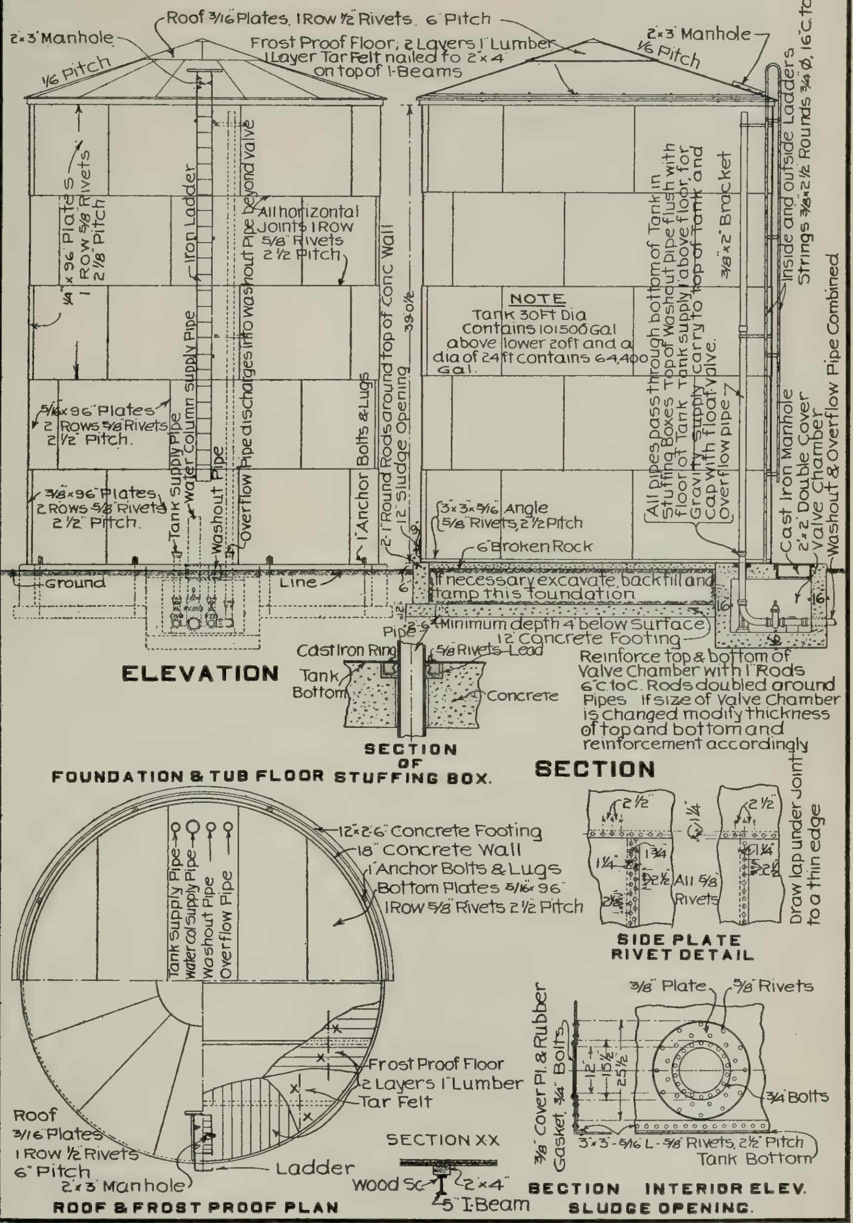
For Steel:

- (a) Tension in plates, 12,000 lbs. per sq. in. on net section.
- (b) Shear in plates, 10,000 lbs. per sq. in.
- (c) Shear on rivets, 10,000 lbs. per sq. in.
- (d) Bearing pressure on field rivets, 18,000 lbs. per sq. in.

STAND PIPE WATER TANK.

WATER SERVICE

1910-1911


Roof 3/16 Plates, 1 Row ½" Rivets. 6" Pitch
2×3' Manhole
1/6 Pitch
Frost Proof Floor; 2 Layers 1" Lumber
1 Layer Tar Felt nailed to 2"×4"
on top of I-Beams
2×3' Manhole
1/6 Pitch
¼"×96" Plates
1 Row 5/8" Rivets
2 1/8" Pitch
Iron Ladder
All horizontal Joints 1 Row 5/8" Rivets 2½ Pitch
Overflow Pipe discharges into washout Pipe beyond valve
Water Column supply Pipe
Tank Supply Pipe
Washout Pipe
5/16"×96" Plates
2 Rows 5/8" Rivets
2½" Pitch.
3/8"×96" Plates
2 Rows 5/8" Rivets
2½" Pitch.
1" Anchor Bolts & Lugs
2-1" Round Rods around top of Conc Wall
12" Sludge Opening
39'0½"
NOTE
Tank 30 Ft Dia contains 101500 Gal above lower 20 ft and a dia of 24 ft contains 64,400 Gal.
All pipes pass through bottom of Tank in Stuffing Boxes. Top of Washout pipe flush with floor of Tank. Tank supply 1' above floor, for Gravity supply carry to top of Tank and cap with float valve.
Overflow pipe
3/8"×2" Bracket
Inside and outside Ladders
Strings 3/8"×2½ Rounds ¾" ⌀, 16" C. to C.
3"×3"×5/16 Angle
5/8" Rivets, 2½ Pitch
6" Broken Rock
Cast Iron Manhole
2'×2' Double Cover
Valve Chamber
Washout & Overflow Pipe Combined
Ground
Line
9"
6"
12"
16"
16"
6"
If necessary excavate, backfill and tamp this foundation
2'-6" Minimum depth 4' below Surface
12" Concrete Footing
Reinforce top & bottom of Valve Chamber with 1" Rods 6" C. to C. Rods doubled around Pipes. If size of Valve Chamber is changed modify thickness of top and bottom and reinforcement accordingly
ELEVATION
Pipe
Cast Iron Ring
5/8 Rivets
Lead
Tank Bottom
Concrete
SECTION OF FOUNDATION & TUB FLOOR STUFFING BOX.
SECTION
12"×2'-6" Concrete Footing
18" Concrete Wall
1" Anchor Bolts & Lugs
Bottom Plates 5/16"×96"
1 Row 5/8" Rivets 2½ Pitch
Tank Supply Pipe
Water col. Supply Pipe
Washout Pipe
Overflow Pipe
Frost Proof Floor
2 Layers 1" Lumber
Tar Felt
Roof
3/16" Plates
1 Row ½" Rivets
6" Pitch
2'×3' Manhole
Ladder
ROOF & FROST PROOF PLAN
SECTION X-X
Wood Sc.
2"×4"
5" I-Beam
2½"
1¼
1¾
1¼"
2½
2½"
All 5/8" Rivets
2½"
1¼
2½
Draw lap under Joint to a thin edge
SIDE PLATE RIVET DETAIL
3/8" Cover Pl. & Rubber Gasket, ¾" Bolts
12"
15½"
25½"
3/8" Plate
5/8" Rivets
¾" Bolts
3"×3"-5/16" L-5/8" Rivets, 2½" Pitch
Tank Bottom
SECTION
INTERIOR ELEV.
SLUDGE OPENING.

Cylindrical.

17. Plates forming the shell of the tank shall be cylindrical and of different diameters, in and out, from course to course.

Workmanship.

18. All workmanship shall be first-class. All plates shall be beveled on all edges for caulking after being punched. The punching shall be from the surface to be in contact. The plates shall be formed cold to exact form after punching and beveling. All rivet holes shall be accurately spaced.

Drift pins shall be used only for bringing the parts together. They shall not be driven with enough force to deform the metal about the holes.

Power riveting and caulking shall be used. A heavy yoke or a pneumatic bucker shall be used for power-driven rivets. Riveting shall draw the joints to full and tight bearing.

Caulking.

19. The tank shall be made water tight by caulking only. No foreign substance shall be used in the joints. The caulking shall preferably be done on the inside of the tank and joints only. No form of caulking tool or work that injures the abutting plate shall be used.

Minimum thickness of plate.

20. The minimum thickness of plates used in the cylindrical part of the tank shall be ¼-in. and in the bottom $\frac{5}{16}$-in.

Joints.

21. Lap joints shall be used for all horizontal joints and for vertical joints in plates not more than ⅜-in. thick. With thicker plates, double butt joints, with inside and outside straps, shall generally be used. The edge of the plate in contact at the intersection of horizontal and vertical lap joints shall be drawn out to a uniform taper and thin edge.

Rivet holes, punching and pitch.

22. The diameter of rivet holes shall be $\frac{1}{16}$-in. larger than the diameter of the rivets used. The punching shall conform to the specifications of this Association for such work on steel bridges. A close pitch, with due regard for thickness of plate and balance stress between tension on plates and shear on rivets, is desirable for caulking.

Gage.

23. The tank shall be equipped with a gage indicator and float, according to the design or selection of the engineer.

Painting.

24. After being completely erected, caulked and cleaned of dirt, rust and scale, all metal work shall be painted, inside and out, with two coats of paint, using the company's standard paint and colors for such work.

Definitions.

25. The words "company," "engineer," "drawings," "as shown" and "this Association" appearing in these specifications are defined as follows:

"Company" means the railway company building a tank under these specifications.

"Engineer" means the engineer of the company.

"Drawings" means the drawings of the tank herein specified and forming a part of these specifications, including such working drawings as the engineer shall prepare or approve.

"As shown" means as shown on the drawings.

"This Association" means the American Railway Engineering and Maintenance of Way Association.

CONCLUSIONS.

The Committee desires that action be taken on this report as follows:

(1) That the plans and specifications for the reinforced concrete tank be received as information and the work continued.

(2) That the specifications for wooden water tank be approved as submitted and published in the Manual.

(3) That the specifications for ordinary iron or steel water tanks be approved as submitted and published in the Manual.

(4) That the specifications for iron or steel water tanks be approved as submitted and published in the Manual.

(5) That the design submitted for wooden water tank be approved as good practice and published in the Manual.

(6) That the design submitted for metal standpipe type of water tank be approved as good practice and published in the Manual.

Respectfully submitted,

C. L. Ransom, Resident Engineer, Chicago & Northwestern Railway, Omaha, Neb., *Chairman.*

Robert Ferriday, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Indianapolis, Ind., *Vice-Chairman.*

James Burke, Engineer Maintenance of Way, Erie Railroad, Cleveland, Ohio.

J. L. Campbell, Engineer Maintenance of Way, El Paso & Southwestern Railway, El Paso, Tex.

H. M. Church, Division Engineer, Baltimore & Ohio Southwestern Railroad, Cincinnati, Ohio.

G. H. Herrold, Engineer Maintenance of Way, Chicago Great Western Railroad, St. Paul, Minn.

E. G. Lane, Engineer Maintenance of Way, Baltimore & Ohio Railroad, Pittsburg, Pa.

A. Mordecai, Consulting Engineer, Cleveland, Ohio.

C. A. Morse, Chief Engineer, Atchison, Topeka & Santa Fe Railway System, Topeka, Kan.

W. A. Parker, Chief Engineer, St. Joseph & Grand Island Railway, St. Joseph, Mo.

L. P. Rossiter, Hazelwood, Pa.

A. D. Schermerhorn, Division Engineer, Union Pacific Railroad, Omaha, Neb.

Committee.

Appendix A.

WATER STATIONS FOR TRACK PANS.

DESIGN OF TRACK PANS.

The Committee has received copies of standards, information relative to design and operation and data from tests of Track Pans used by different railroads in this country. The standards, information and tests have been analyzed and compared, with the following results:

ECONOMICS.

Track Pans are primarily used to enable trains to take water while in motion. Their use up to the present time has been almost entirely confined to fast passenger trains making long runs between regular stops, but with increased efficiency from design of pans, methods of feeding and keeping water from freezing and improved scoops, the track pan is being adopted for freight trains, especially where it is desirable to keep trains moving, and in consideration of the excess cost of stopping and starting, the wear and tear of rolling equipment and the danger of breaking draft gear. The relative economy of the delivery of water to locomotives by the Track Pan and by the tank spout or standpipe is dependent from an operating standpoint upon the following:

First cost, interest, depreciation, maintenance, operation, including cost of water, loss of energy expended in drawbar pull overcoming the dynamic pressure of water from pan or scoop, speed of trains, ruling grade, loss of time and cost of stopping and starting, including wear and tear on rolling equipment, etc. These factors will have a wide variance for different locations and designs; hence each particular case should be figured separately.

LOCATION.

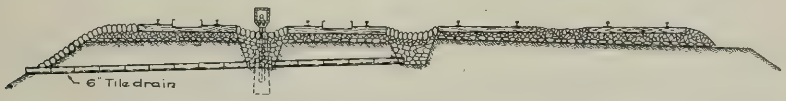
Alinement.—The Track Pan should preferably be located on tangent, although it is possible to place same on curves up to three degrees and obtain fair results. The Pennsylvania Railroad and the Philadelphia & Reading Railroad have pans on two-degree curves which have proven satisfactory. The disadvantage of placing pans on curves, besides some additional first cost and cost of maintenance, are the difficulty of keeping pans in surface and some additional waste of water from spray and water washing over sides.

GRADE.

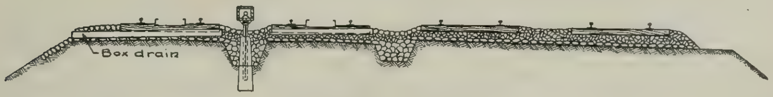
The Pan should be laid on a level grade with grade of approaches such as to allow minimum speed required over pan to properly take water, and for this reason Track Pans should be away from stations, yards, railroad crossings, drawbridges, etc.

FOUNDATION.

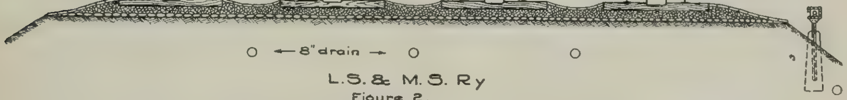
Pans are set directly on ties, the ties being dapped out about two inches and width of pan to form seat and allow top of pan to be the same elevation as top of rail. The pan is held in position and anchored by side lugs fastened to ties by ordinary or special form of spike or bolt with proper allowance for expansion and contraction of the material. The section of tie should be larger than ordinary and of white oak or other hard wood. On account of the large amount of waste water thrown over sides of pan, special attention should be given to drainage. Figs. 1, 2 and 3 show the standard types of foundation under ties of the New York Central & Hudson River Railroad, Lake Shore & Michigan Southern Railway and the Baltimore & Ohio Railroad. It is not desired to discuss the merits of these types with the information at hand, but it is believed that there are several different designs of foundation possible which will give satisfactory results.



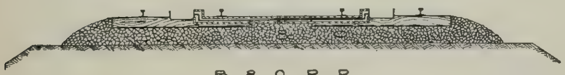
N. Y. C. & H. R. R. R.
Figure 1-A.



N. Y. C. & H. R. R. R
Figure 1-B.



L. S. & M. S. Ry
Figure 2.



B. & O. R. R.
Figure 3.

CROSS SECTIONS.
SHOWING TRACK DRAINAGE
FOR
TRACK PANS.

LENGTH.

The length of pan is one of the factors which determines the capacity. The economical length is dependent on the width of pan, size and adjustment of scoop, quantity of water to be taken into locomotive tanks during a given time and speed and time taken to fill pan.

Table 1 shows the length of pan used by different railroads. Table 2 shows the average number of gallons of water taken into locomotive tank with the corresponding number of gallons removed from tank and wasted per foot of length of pan by a scoop of cross-section 6½ in. by 12 in. and pans 19 in. and 29 in. wide for speeds of from 20 to 60 miles per hour.

TABLE NO. 1.

Railroad	Length (Feet)	Cross-Sections (Inches)		Method of Heating
		Width	Depth	
Penna. R. R.........	1200, 1500 & 1800	19 and 29	6	Two-pipe circulation
L. S. & M. S. Ry....	2000	19	7½	Steam, two-pipe circulation and one-pipe circulation
B. & O. R. R.......	1200	19	6	Steam
Mich. Central R. R..	1600	19⅝	7	Steam
N. Y., New Haven & Hartford R. R.....	1250	19	6	Steam
New York Central & Hudson R. R. R...	1400	23⅜	7	Steam

TABLE NO. 2.

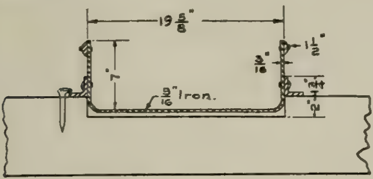
Note.—(1) This table shows the average quantities taken from track pan, taken into tank and wasted, from several tests, with average conditions. These quantities are dependent on the design of pan and scoop and depth of emersion of scoop in water.

Width of Pan (Inches)	Speed—M. P. H.	Number of Gallons Taken Into Locomotive Tank			Number of Gallons Taken Out of Track Pan = 100%			Per Cent of Waste
		Per Ft. of Length of Pan	For Length of Pan= 1200 Ft.	For Length of Pan= 2000 Ft.	Per Ft. of Length of Pan	For Length of Pan= 1200 Ft.	For Length of Pan= 2000 Ft.	
19	20	1.70	2040	3400	2.10	2520	4200	.19
19	30	1.90	2280	3800	2.20	2640	4400	.14
19	40	2.00	2400	4000	2.20	2640	4400	.09
19	50	1.85	2220	3700	2.35	2820	4700	.21
19	60	1.70	2040	3400	2.80	3360	5600	.39
29	20	2.20	2640	4400	2.90	3480	5800	.24
29	30	2.30	2760	4600	2.90	3480	5800	.21
29	40	1.90	2280	3800	2.65	3180	5300	.28
29	50	1.70	2040	3400	2.70	3240	5400	.37
29	60	1.50	1800	3000	3.00	3600	6000	.50

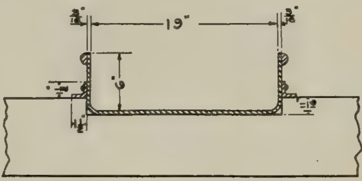
CROSS-SECTION.

The different pans in use at the present time are almost exclusively of built-up steel sections, although pans of cast-iron and wood have been used with less success. The type of section is a matter of structural detail. The important considerations are rigidity, life and first cost. The depth should be 7 in. to 7½ in. so as to allow top of pan to be at same elevation as top of rail with a maximum dap in tie of not more than 2 in. to 2½ in.

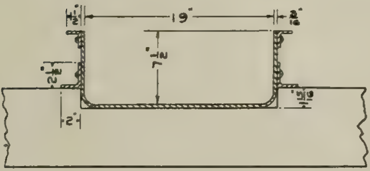
A width of 19 in. has been found to be the most efficient and economical for the operation of fast-speed trains and combined fast and slow-speed trains. The larger width of 29 in. has some advantage in the quantity water taken into locomotive tank per foot of length of pan for slow speeds, but this is partly offset by the additional waste. Figs. 4, 5, 6, 7, 8 and 9 show different sections of pans that have been found to meet the requirements.



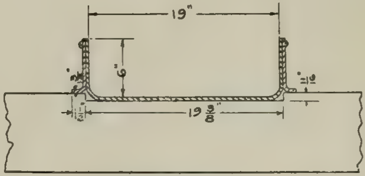
Michigan Central R.R.
Figure IV.



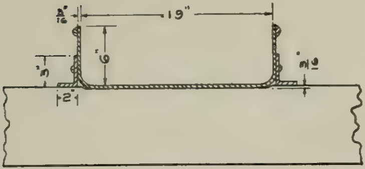
B. & O. R. R.
Figure V.



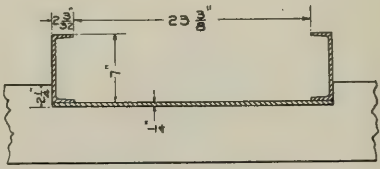
L. S. & M. S. Ry.
Figure VI.



Pennsylvania R.R.
Figure VII.



N Y. N. H. & H. R. R.
Figure VIII.



N. Y. C. & H. R. R. R.
Figure IX.

END INCLINES.

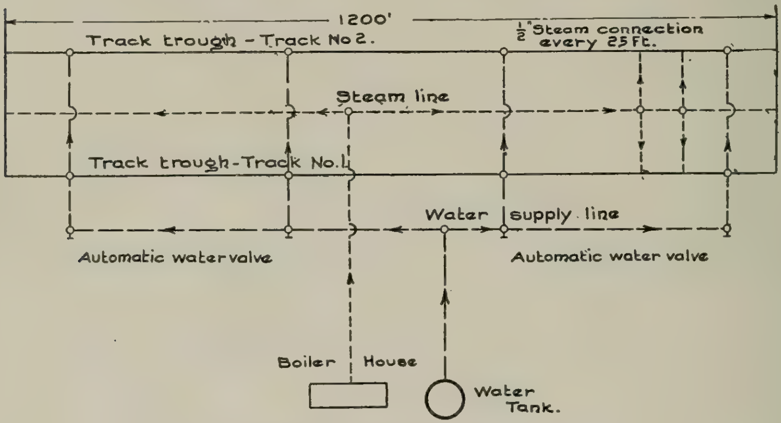
The end inclines should be substantially built to resist the larger amount of impact to which they are at times subjected by badly adjusted scoop, hanging under gear, etc. They should be built as a part of the body of pan forming ends. The rate of incline in direction of travel, in and out of pan, should not be more than ¾-in. to 1 ft. 0 in. of length and of perfectly smooth surface.

WATER CONNECTIONS.

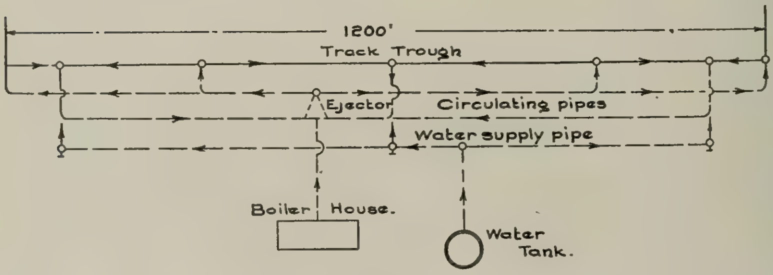
The size and number of supply pipes should be determined from the pressure, number of openings and minimum time required to fill pan. For expansion and contraction proper provision should be made in the form of corrugated or rubber hose, or by packed or special joints. The placing of pipes in cross tunnels at inlets allows the taking care of water run off from broken pipes, assists in drainage and facilitates repairs. There are two methods of regulating the filling of pans, viz.: (1) by man operation; (2) automatic valve. The latter method is generally the more dependable and under average conditions should give the more economical and satisfactory result. The inlet should be so designed as to allow the minimum disturbance by flow of water into pan with corresponding minimum loss from friction. The deflector, enlargement of section of pipe at inlet and perforated plates are used at the present time.

METHODS OF HEATING.

To keep the temperature of water in pan below the freezing point or to raise the freezing point to avoid or remove the formation of ice at top



STEAM HEATING METHOD
Figure X.



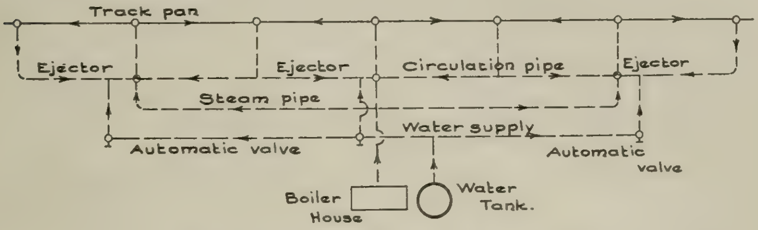
TWO PIPE CIRCULATION METHOD
Figure XI.

of pan so that water can be taken during freezing temperature, the following methods are used:

(1) Blowing steam in water through nozzles in sides of pans spaced at intervals of 20 ft. 0 in. to 30 ft. 0 in. along length of pan.

(2) Circulating the water in pan by means of a pump and heater or an injector.

Figs. 10, 11 and 12 show diagram outlines of the steam heating and one and two pipe circulating methods respectively. The results obtained by the steam heating method have been mostly satisfactory, but on account of the large amount of energy expended and the number of connections, etc., to keep up there is a general tendency towards the use of the circulating method, although results obtained up to the present time have not been entirely satisfactory.



ONE PIPE CIRCULATION METHOD.
Figure XII.

THE DEVELOPMENT OF THE DESIGN OF TRACK PAN.

The first track pan of which any record is given was installed on the London & Northwestern Railway of England, about 1857, and was known as the Ramsbottom Track Tank, its inventor being Sir J. Ramsbottom. The first track pan in this country was installed by the New York Central & Hudson River Railroad in 1870, at Montrose, between New York and Albany. It was for the use of the fast Saratoga trains at that time, was supplied with water by a hand pump, and no provision was made against cold weather, its use being discontinued in the winter.

The first track pan in which provision was made for filling the pan by steam pump and the heating of water in pan during the winter to prevent freezing, was installed by the Baltimore & Ohio Railroad in 1889 at Stanton, between Baltimore and Philadelphia, for the use of their fast passenger trains between these points. Fig. No. XIX shows the plan and general details of this pan, which has been used continually up to the present time. The filling of this pan is regulated by man operation and the water in pan heated during freezing temperature by steam admitted through nozzles in sides of pan.

The development of the design of Track Pan since the first installation by the Baltimore & Ohio Railroad has been practically inappreciable, but at the present time this method of delivery of water to locomotives is receiving the attention of the operating and engineering departments of several railroads and the further development of the track pan and also the locomotive scoop is to be expected.

In this connection the track pan water station now being built by the Pennsylvania Lines West of Pittsburg at Fort Wayne, Ind., plan and general detail of which are shown in Fig. XX, and by the Lake Shore & Michigan Southern Railway at Painesville, O., plans and general details of which are shown in Figures XXI, XXII, XXIII, XXIV, and XXV, and a description by Mr. H. H. Ross, assistant engineer, Appendix B, show much development in the general layouts and development of details. These plants, at Fort Wayne and Painesville, when in operation, should afford a study of the relative efficiency of the one and two pipe circulating systems, respectively, in their latest development.

THE ACTION OF SCOOP IN PAN.

The action of the scoop while taking water from the pan is more or less as a blunt plow. At speeds above thirty miles per hour it is very apparent that the velocity of the water entering into the scoop is less than the velocity of the tender; this has the effect of throwing out of the pan, especially at higher speeds, the water on either side of the point of the scoop and between it and the sides of the pan. As the speed diminishes below thirty miles per hour a wave action is set up in front of the dipper, the water being piled up until it falls over the sides. This wave increases in size up to the point where the velocity imparted to it is less than that necessary to overcome the resistance due to gravity and friction, when, of course, no more water is lifted.

The dynamic pressure exerted by a surface moving in still water is equal to that produced by a stream flowing with the same velocity against a surface at rest. By the action of the scoop in the pan a dynamic pressure is produced in the opposite direction to the motion of scoop, the resultant of which is counteracted by the draw bar pull.

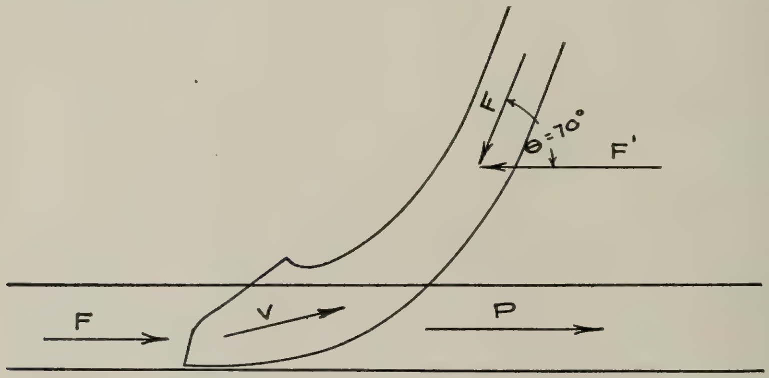
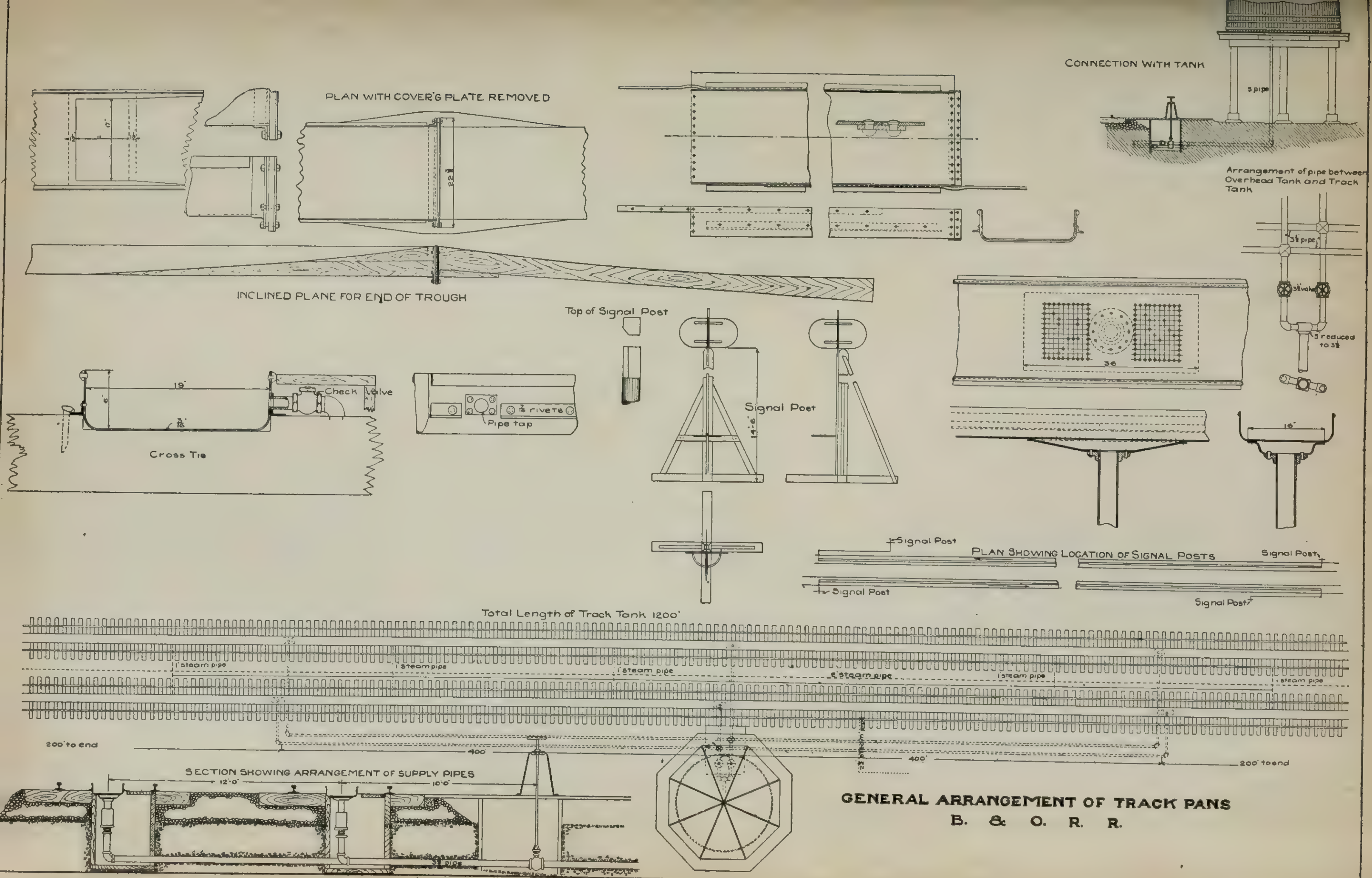
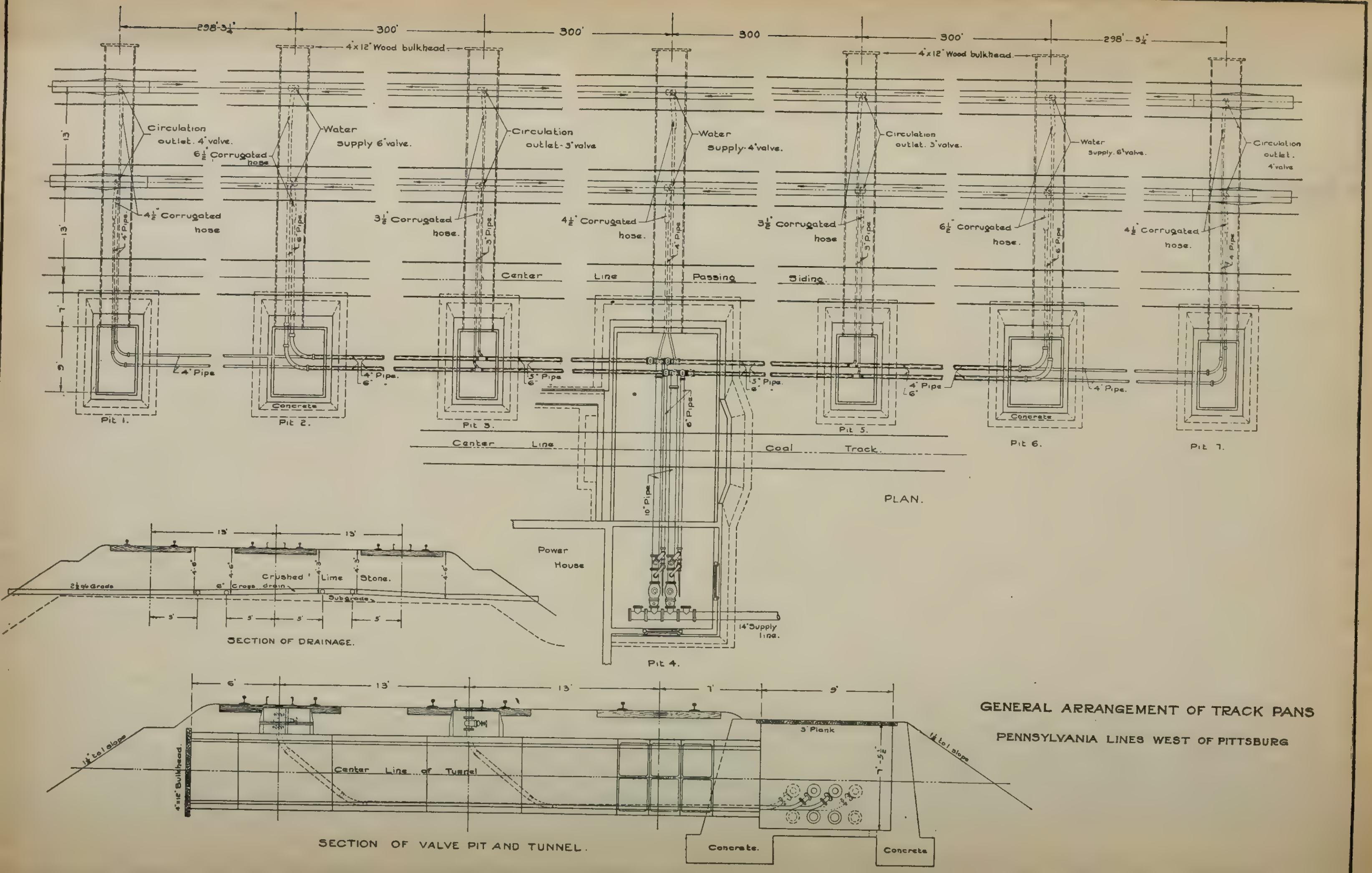


FIG. 1.



GENERAL ARRANGEMENT OF TRACK PANS
B. & O. R. R.

Figure XIX.



GENERAL ARRANGEMENT OF TRACK PANS

PENNSYLVANIA LINES WEST OF PITTSBURG

Let F = Force of impulse in pounds.
Let F^1 = Component of F in direction of initial motion.
Let P = Dynamic pressure in pounds produced in direction of initial motion = Drawbar Pull.
Let W = Weight of water removed from pan per second.
Let V = Velocity of scoop in pan in feet per second.
Let G = Acceleration due to gravity = 32.2.

$$F = W\frac{v}{g} \quad \text{(1)}$$

The water from pan entering the inside surface of scoop and the impact produced, by water coming in contact with the outside surfaces of scoop develops the dynamic pressure and drawbar pull. The dynamic pressure produced by the water entering the inside surface of scoop depends upon its change of direction from Fig. (1).

$$P = F - F^1 = F\,(1 - \cos\theta) \quad \text{(2)}$$

Substituting for F its value as given in . . . . (1)

$$P = (1 - \cos\theta)\,W\frac{v}{g} \quad \text{(3)}$$

Assuming $\theta = 70$ deg. which is a very fair approximation for the scoops used at the present time and substituting in (3) the values for $(1 - \cos\theta)$ and g.

$$P = .02043\ W.V \quad \text{(4)}$$

The quantity of water which enters the inside surface of scoop is equal to the quantity of water taken into tank and the difference between this quantity and the total quantity removed from pan is the waste which produces the impact by coming in contact with outside surfaces of scoop. The effect of this impact cannot be determined, but a fair assumption is that it will produce the same dynamic pressure as the same quantity of water entering scoop. Neglecting friction and other minor disturbance which are practically negligible the value of P as given in (4), in which W = weight of water removed from pan per second, is a fair approximation of the drawbar pull.

Drawbar pull = P = .02043 W.V.

Using the values of W and V for 19 in. pans as derived from table 2—the drawbar pull is found to be:

TABLE NO. 3.

Speed in Miles per Hour.	Drawbar Pull in Pounds.	Developed Horse Power.
20	308	16.00
30	727	58.00
40	1292	137.00
50	2156	287.00
60	3698	592.00

These values of the drawbar pull are in close approximation with values as found in actual tests. It will be noted that the drawbar and corresponding developed horsepower, for high speeds, would consume a large part of the available horsepower of the locomotive, but as the increase in the kinetic energy of the moving train is in much greater proportion, for the higher speeds, the retardation effect of the scoop in water will not be very apparent although it will effect some slowing up of the train.

In considering the efficiency of a particular scoop and pan, the two important considerations are:

(1) The total amount of water taken into the locomotive tank from the pan.

(2) The total amount of water wasted from the pan.

Prof. I. P. Church of Cornell University made a mathematical investigation of water scoops as follows:

(1) Considering an open trough with sides of sufficient height to keep water from flowing over (Fig. A).

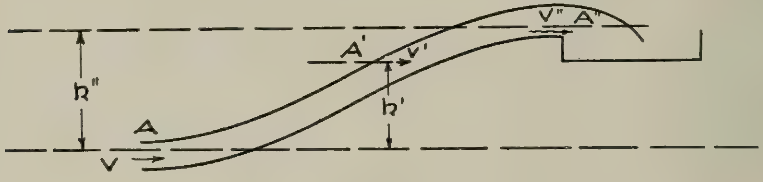


FIG. A.

$$h = \frac{V^2}{2g}, \quad V = \sqrt{2gh} \quad \ldots\ldots (1.)$$

From Bernoullis Law—"At any section of a tube or pipe, under steady flow without friction, the pressure-head plus the velocity head is equal to the hydrostatic head that obtains when there is no flow."

$$\frac{V'^2}{2g} = \frac{V^2}{2g} - h' \quad \ldots\ldots (2.)$$

Let F = sectional area of the stream at the bottom.

Let F′ = sectional area of the stream at any height.

Since with a steady flow this product is constant (neglecting all friction).

$$F'V' = FV \quad \ldots\ldots (3.)$$

$$F' = \frac{FV}{V'} = \frac{FV}{\sqrt{V^2 - 2gh'}} \quad \ldots\ldots (4.)$$

The effect of a diminished velocity is to produce a thickening or increase of depth (if width of trough is uniform) of stream. It is evident that the top of the scoop at A must not be permitted to dip too far below the surface, i. e., too great a value must not be given to the sectional area F at A, otherwise the sections above, all of which are larger than F, would become too great and the water would tend to overflow the sides. Assuming a convenient low value for the velocity V″ (not calling for too great a depth of stream) at the highest point A'', the greatest height to which the water could be raised with a given velocity V at A, can be computed from the equation:

$$h'' = \frac{V^2}{2g} - \frac{V''^2}{2g} \qquad (5.)$$

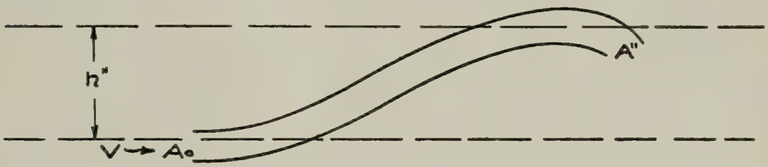
Friction is provided for by introducing a single "loss of head" (depending on the square of the velocity nearly and also on the size of the section and the depth) of form.

$$\frac{m}{2} \cdot \frac{V^2 + V''^2}{2g} \qquad (6)$$

Substituting

$$h'' = \frac{V^2}{2g} - \frac{V''^2}{2g} - \frac{m}{2} \cdot \frac{C^2 + C''^2}{2g} \qquad (7.)$$

closed pipe.



For a steady flow in the pipe from A_0 to A'', Bernoullis' law gives rise to the relation:

$$\frac{V^2}{2g} = h'' + \frac{V''^2}{2g} + m' \frac{V^2}{2g} \qquad (8.)$$

V'' is the slow velocity of the water at A'', and M' is a coefficient whose value may vary from 0.10 to 0.50 (judging from results of experiments with pipes and Venturi meters).

Substituting:

$V'' = F v$

F'' the value of that particular velocity of the locomotive for which (with given h'' and dimensions of pipe) the velocity of the water through the tip would be equal to that of the locomotive over the track. In other words, no water would be thrown sideways by the advancing tip, and there would be less splashing.

$$V = \frac{\sqrt{2gh''}}{\sqrt{1 - \left[m' + \left(\frac{F}{F''}\right)^2\right]}} \qquad (9.)$$

Example:

$$\left.\begin{array}{l} h'' - 15'\ 0'' \\ F'' - 8\,F \\ m' - 0.10 \end{array}\right\} v = 33' - 0'' \text{ a sec.} = 22 \text{ m. p. h.}$$

The conclusions from the above mathematical reasoning are that 22 M. P. H. is the minimum speed for taking water, and at 25 M. P. H.

water is scooped into the tender satisfactorily, although more water is scooped into the tender at higher speeds, 40 to 50, M. P. H. working about the best. These conclusions have been proven by practical tests. It should further be observed that the adjustment of the scoop is very important.

The future development of the design of track pan will depend to a large extent upon the development of the design of the scoop, which affords more principals of design than the track pan, and it is possible that the size and general arrangement will be entirely changed to obtain greater efficiency. With a set design of scoop the design of track pan can be developed to give the maximum efficiency of the combined scoop and pan. The development of the design of scoop is being given consideration by several railroads.

The Pennsylvania Railroad made several tests of track pans and scoops at Atglen, Pa., in 1906. The results from these tests are based on the actual conditions found. The pans are on a two-degree curve with the outer rail elevated and pans more or less out of surface, due to difficulty in keeping this portion of road, which is a fill, in proper condition. The results from these tests are shown as follows:

Table 4—Standard scoop and dipper with standard 19-in. and 29-in. pans, as shown in Figs. XIII and XIV.

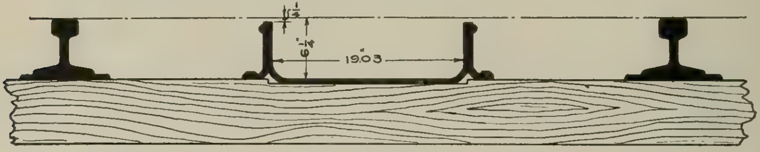


Figure XIII.

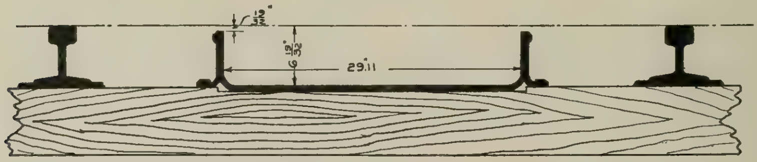


Figure XIV.

Table 5—Standard scoop and dipper with a standard 19-in. pan.

Table 6—Standard scoop and dipper with a 29-in. pan with lips as shown in Fig. XV.

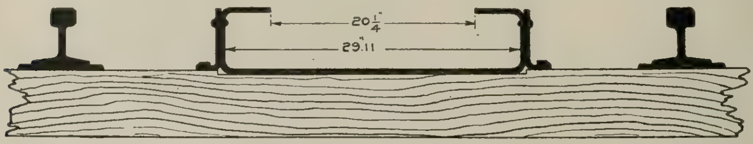


Figure XV.

Table 7—Standard scoop and type "A" dipper as shown in Fig. XVII, with a 29-in. pan, with lips.

The results as shown in Table 4 are from the first tests made at Atglen and are more or less preliminary. Tables 5 and 6 allow a study of the efficiency of the standard scoop in the 19-in. and 29-in. pans. It can be readily concluded that the best results are obtained with the 19-in. pan. Table 7 shows the results obtained from the standard scoop and a special form of dipper with the 29-in. pan. The results obtained show a decrease in the efficiency of this special form over the standard form of dipper.

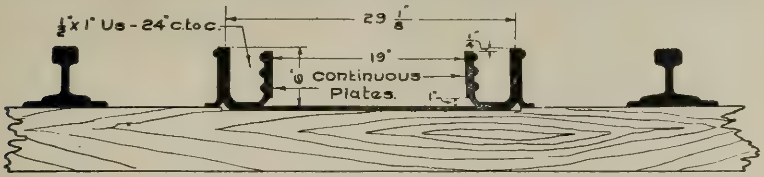


Figure XVI.

The Pennsylvania Railroad is making very exhaustive tests of water scoops and track pans, using several special forms of dippers and shields

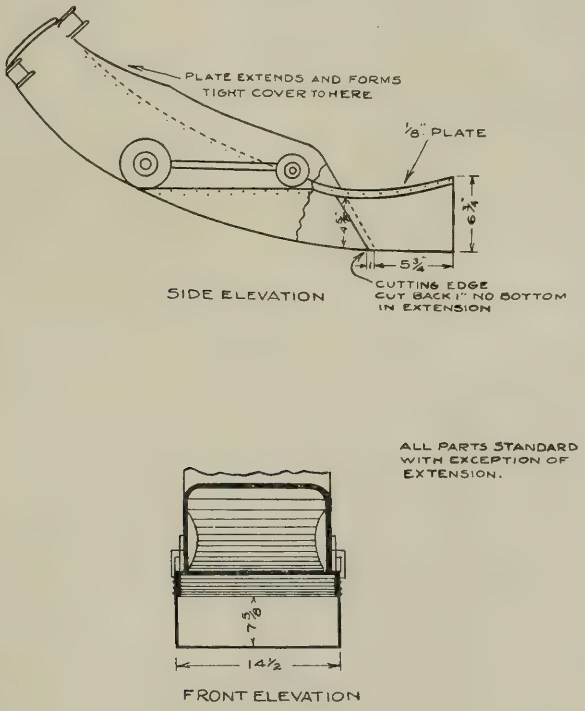


PLATE EXTENDS AND FORMS TIGHT COVER TO HERE
1/8" PLATE
6¾"
5¾"
CUTTING EDGE CUT BACK 1" NO BOTTOM IN EXTENSION
SIDE ELEVATION
ALL PARTS STANDARD WITH EXCEPTION OF EXTENSION.
7⅝
14½
FRONT ELEVATION

Figure XVII.

STANDARD SCOOP WITH TYPE "A" DIPPER

in connection with their standard and special forms of scoop with their standard 19-in. and 29-in. pans, as shown in Figs. XIII and XIV, and a special form of pan, as shown in Fig. XVI. The results obtained from these tests should furnish considerable information for the further development of the track pan and scoop.

Fig. XVIII shows plot of results from tests on track pans made by the Lake Shore & Michigan Southern Railway. This report on track pans is submitted as a progress report, and the Committee asks that the subject be reassigned for the next year.

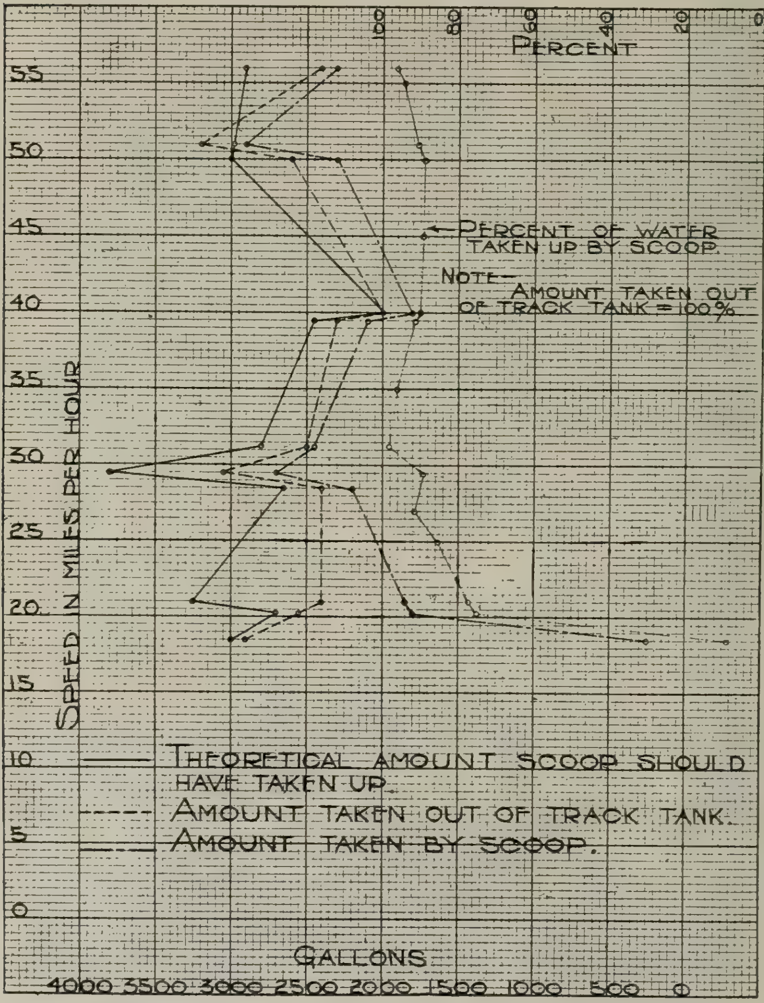


Figure XVIII.

TABLE 4—TEST OF TRACK TANKS. ATGLEN, PA., PHILADELPHIA DIVISION JULY, 1906. NO DEFLECTOR USED. SUMMARY TABLE.

Test No.	Speed M. P. H.		Water Out of Track Pan			Water to Tender			Water Wasted		
	Nominal	Average	Total Gallons	Per Foot of Length, Gallons	Per Cent.	Total Gallons	Per Foot of Length, Gallons	Per Cent.	Total Gallons	Per Foot of Length, Gallons	Per Cent.
29-INCH TRACK PANS											
1	20	23.8	2431.9	1.638	100	1960.8	1.324	80.6	471.1	0.314	19.4
2	30	31.1	3195.9	2.162	100	2525.7	1.706	79.0	670.2	0.456	21.0
3	40	39.5	3918.6	2.670	100	2741.3	1.870	70.0	1177.3	0.800	30.0
4	50	47.7	4258.1	2.902	100	2725.3	1.855	64.0	1532.8	1.047	36.0
5	60	63.8	5135.7	3.449	100	2854.8	1.915	55.5	2280.9	1.534	44.0
19-INCH TRACK PANS											
1	20	23.0	3690.1	2.498	100	2398.6	1.623	65.0	1291.5	0.875	35.0
2	30	32.4	3897.3	2.640	100	2860.6	1.937	73.4	1036.7	0.703	26.6
3	40	42.0	3672.9	2.491	100	3089.5	2.095	84.1	583.4	0.396	15.9
4	50	50.0	3996.1	2.738	100	3109.9	2.087	77.8	886.2	0.651	22.2
5	60	59.6	4521.1	3.098	100	3374.8	2.312	74.6	1146.7	0.786	25.4

TABLE 5—TEST OF TRACK TANKS. ATGLEN, PA., PHILADELPHIA DIVISION, OCTOBER, 1906. 19-INCH PAN.

SUMMARY TABLE.

Standard Scoop and Dipper Scoop Set ⅝ Inch from Bottom of Pan.

Test No.	Speed M. P. H.		Water Out of Track Pan			Water to Tender			Water Wasted			Immersion of Scoop (in Motion) in Water, Inches
	Nominal	Average	Total Gallons	Per Foot of Length, Gallons	Per Cent.	Total Gallons	Per Foot cf Length, Gallons	Per Cent.	Total Gallons	Per Foot of Length, Gallons	Per Cent.	
1	20	22.6	2655	1.866	100	2372	1.667	89.41	283	0.1991	11.59	2.85
2	20	23.2	2709	1.876	100	2597	1.776	94.62	112	0.0998	5.38	2.92
3	20	21.3	2999	2.050	100	2717	1.842	89.85	282	0.2080	10.15	3.00
4	30	32.6	2968	2.915	100	2792	2.791	95.75	176	0.1242	4.25	2.99
5	30	31.6	3241	2.252	100	3065	2.081	92.53	176	0.1707	7.47	3.03
6	30	31.2	2782	1.958	100	2673	1.879	95.85	109	0.0786	4.15	2.88
7	40	42.6	2761	1.925	100	2554	1.781	92.55	207	0.1444	7.45	2.76
8	40	39.7	2886	2 046	100	2854	2.021	98.90	32	0.0247	1.10	2.85
9	40	39.9	3084	2.145	100	2924	3.036	94.75	160	0.1093	5.25	2.67
10	50	50.1	2521	1.853	100	2403	1.769	95.50	118	0.0839	4.50	2.65
11	50	49.2	2498	1.849	100	2137	1.582	85.50	361	0.2672	14.50	2.87
12	50	49.5	2671	1.916	100	2344	1.684	87.82	327	0.2321	12.18	2.80
13	60	60.7	1512	1.124	100	763	0.567	50.45	749	0.5571	49.55	1.03
14	60	63.6	1384	0.985	100	658	0.468	47.55	726	0.5173	52.45	0.85
15	60	63.7	1527	1.069	100	965	0.677	63.35	562	0.3921	36.65	0.58

TABLE 6—TEST OF TRACK PANS. ATGLEN, PA., PHILADELPHIA DIVISION, NOVEMBER, 1906. 29-INCH PAN WITH LIPS.

Standard Scoop and Dipper Scoop Set ⅝ Inch from Bottom of Pan.

Test No.	Speed M. P. H.				Scoop in Water			Water in Cubic Feet.					Immersion of Scoop (in Motion) in Water, Inches.
											Per Foot of Length		
	Nominal	Entering	Leaving	Average	Distance, Feet	Time, Seconds	Ent. Feet from End	Out of Pan	Into Tender	Difference Spilled	Into Tender	Spilled	
1	20	23.2	23.6	23.4	1365	39.78	37	452.5	401.8	50.7	0.2944	0.0371	3.10
2	20	23.0	23.8	23.4	1352	37.54	100	437.4	417.0	20.4	0 3233	0.0151	5.10
3	20	23.8	24.2	24.0	1353	38.59	40	425.1	397.5	27.6	0.2938	0 0240	2.96
4	30	34.8	34.0	34.4	1290	25.83	38	464.5	408.0	56.5	0.3163	0.0437	3.22
5	30	33.0	33.4	33.2	1332	27.46	35	464.5	428.0	36.5	0.3289	0.0274	3.26
6	30	32.6	31.8	32.2	1431	29.96	27	492.1	460.3	31.8	0.3217	0.0222	3.20
7	40	39.0	39.0	39.0	1397	24.66	28	452.5	405.0	47.5	0.2899	0.0340	3.10
8	40	39.0	38.2	38.6	1396	24.55	32	476.6	420.3	56.3	0.3012	0.0403	3.28
9	40	38.2	38.2	38.2	1147	20.38	38	401.5	331.8	69.7	0.2021	0.0554	3.28
10	50	49.5	49.0	49.3	1297	17.76	37	410.0	325.3	84.7	0.2508	0.0054	2 85
11	50	49.2	48.2	48.7	1256	17.57	35	382.8	322.0	60.5	0.2564	0.0482	3.03
12	50	49.8	48.6	49.2	1257	17.42	43	422.3	300.8	121.7	0.2385	0.0967	2.89
13	60	61.8	62.0	61.9	1388	15.28	40	226.0	117.3	108.7	0.0845	0.0784	0.82
14	60	61.2	61.6	61.4	960	10.57	41	186.8	89.5	97.3	0.0934	0.1014	1.15
15	60	61.3	60.3	60.8	1430	15.94	57	392.1	264.8	127.3	0.1853	0.0891	2.25

TABLE 7—TEST OF TRACK TANKS. ATGLEN, PA., PHILADELPHIA DIVISION, NOVEMBER, 1906. 29-INCH PAN WITH LIPS.

Standard Scoop and Type "A" Dipper Scoop Set ⅝ Inch from Bottom of Pan.

Test No.	Speed M. P. H.		Water Out of Track Pan			Water to Tender			Water Wasted			Immersion of Scoop (in Motion) in Water, Inches
	Nominal	Average	Total Gallons	Per Foot of Length, Gallons	Per Cent.	Total Gallons	Per Foot of Length, Gallons	Per Cent.	Total Gallons	Per Foot of Length, Gallons	Per Cent.	
1	20	18.7	3408	2.365	100	2121	1.472	62.24	1287	0.893	37.76	2.56
2	30	35.2	3292	2.774	100	2962	2.495	89.94	330	0.279	10.06	3.38
3	40	37.9	3272	2.789	100	2607	2.222	79.67	665	0.567	20.33	3.12
4	40	36.8	3272	2.676	100	2862	2.348	87.75	410	0.328	12.25	3.23
5	50	54 0	1870	1.256	100	788	0.542	43.15	1082	0.714	56.85	0.78

Appendix B.

DESCRIPTION OF "ONE PIPE CIRCULATION METHOD" TRACK PANS AS INSTALLED BY THE LAKE SHORE & MICHIGAN SOUTHERN RY. CO., AT PAINESVILLE, OHIO.

By H. H. Ross, Assistant Engineer.

The question of installation and operation of track pans is even now in the development stage, and each pan installed brings in some new feature which has not been previously covered, either by our road or others.

The development of track pan outlined in an article in the Railroad Gazette of March 13, 1908, covers the various stages of the development up to the date of that article, but since this article was written we have changed our construction in various minor details, the principal ones being that we have gone back to the narrow pans, or those of 19 in. width and have changed our methods of heating the track tanks during the cold weather, installing at the present time what we call one pipe circulation method. In a general way at our track pans we want to bring out these features:

(1) That the track under the pans shall be as near as possible the regular construction of track on other parts of the road so that the section men can maintain and handle the ballasting of this track under the track pans as easily as they can other parts of their track work, hence it is desirable to eliminate all rigid steam or water connections.

(2) It is desired to have the water connections so made to the pans that as soon as a train has scooped, the pans will be filled with water again in the shortest possible space of time that a train following the block of the one ahead will be able to obtain a supply of water. This we accomplish by installing water connections to the pans and control the valves for these connections by automatic means, so that if the water level in the pans fall the valves immediately open and fresh water runs in.

(3) Our company believes it is just as important to have freight trains scoop as it is for passenger trains and that with double heads each engine should be able to obtain a full tank of water. With our experience we have found that track tanks 2,000 ft. long are ample to meet the above conditions, and our standard pan at the present time is being built 2,000 ft. long.

(4) It is desired to have the simplest arrangement possible for keeping the pans from freezing in the winter, and yet have a system that will keep all pipes and other breakable parts as far away from the track as possible, and this we believe we accomplish in our latest scheme of heating the water by what we call the single pipe circulation system. This all is diagrammatically represented in Fig. XII, "one pipe circulation

method." The diagram represents a track pan 2,000 ft. long connected at seven tunnels, equally spaced, to a 4 in. circulation pipe thus forming loops; outside of the circulation pipes a steam line is laid and ejectors installed as indicated. These ejectors cause the water to circulate, as shown by arrows in the diagram and sufficient heat is added to the water, by means of these ejectors used for circulating the water, to prevent it from freezing in the coldest weather.

In this same figure is also shown diagrammatically the water supply which is connected to the track pans through the same pipe as the ejectors work on. This water supply is controlled by automatic valves, and as soon as the water in the track pans is lowered by a train scooping, the valves immediately open and fresh water is supplied, which, it will be noticed, flows in the same direction as the ejectors force the water in circulating and heating.

The installations we have installed this year are of this type, and the principal details of the system are shown on Fig. 2, which represents the general arrangement of this installation.

Fig. 3, represents the details of the center manhole and tunnel, and shows the way the tunnels are installed, methods of connecting the ejectors and automatic valves.

Fig. 4 represents the manhole between the ejectors, and shows the details of tunnel and water connections, also the means used for flushing and washing out the circulation pipes. This plan also shows details of expansion joint of the steam main and is run into this manhole for two reasons:

(1) By using a loop in the steam line we can confine all of the expansion to one spot, and second by running this loop in the manhole more or less heat is supplied and there is no danger of the valves or pipes freezing.

Fig. 5, is a plan showing the powerhouse used for supplying the ejectors with steam in the winter time.

Fig. 6, is a plan showing the way the steam line is protected and supported, which supplies the ejectors.

It will be noticed from these plans that there are no rigid connections and track can be raised or ballasted without interferring with any pipe connections.

In the past we have had a large amount of trouble in maintaining our track across the track pans, due to the fact that the waste water washed the ballast out from under our ties and caused the track to ride badly. This we have prevented entirely by laying 8 in. tile drains between tracks throughout the length of the pan connecting these tile drains at each tunnel and disposing of the water through sewers connected to these tunnels. In addition to the track drains we protect the ballast from washing out by paving between tracks and outside of the tracks with large flat flagstones, which answer two purposes.

(1) These stones are very heavy and the water does not have sufficient force to dislodge them.

(2) By paving with these large stones the water has a quick run-off and the largest amount of it gets away quickly, so that it does not have a chance to soak into the embankment.

Our ballast cross-section across the track pans is somewhat heavier than we use at other points of the road and we try as much as possible to meet these conditions:

First, cover the top of the original grade with granulated slag or pave with flagstone to prevent the clay from working up. Second, we put on these prepared surfaces about 18 in. of crushed stone ballast below the bottom of the ties, and on top of this we again pave with large flagstones, as outlined in the paragraph above.

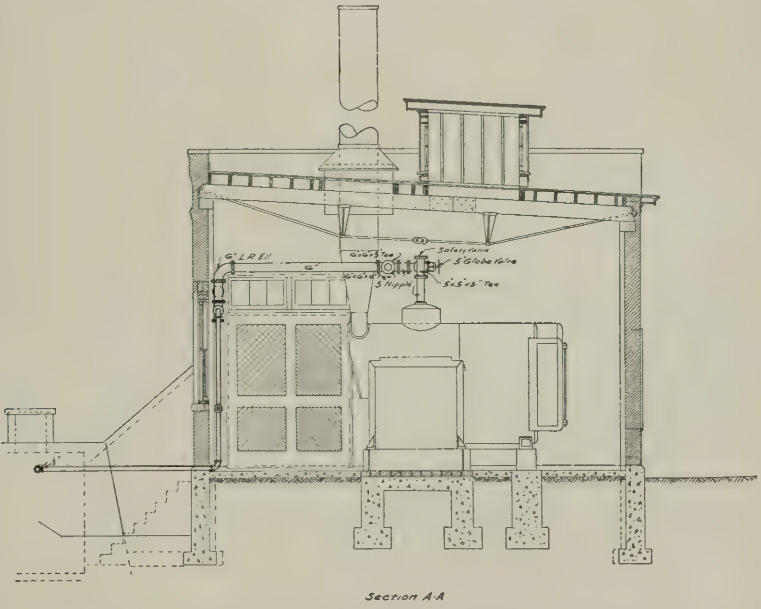
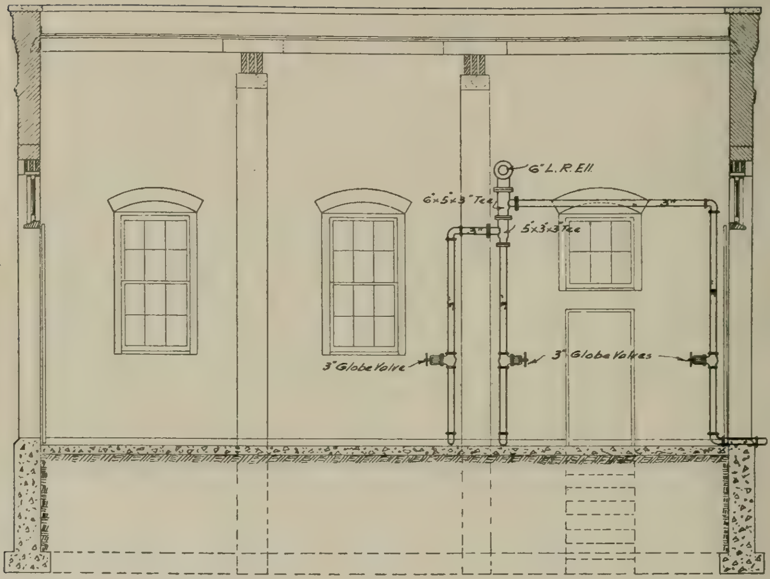


Fig. XXIV.—Boiler House for Track Troughs—Lake Shore & Michigan Southern Railway.



Section B-B

FIG. XXIV.—BOILER HOUSE FOR TRACK TROUGHS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

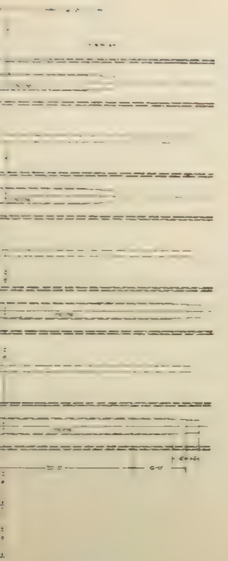


FIG. XXI

[illegible] System Standard Track Troughs, Lake Shore & Michigan Southern Railway

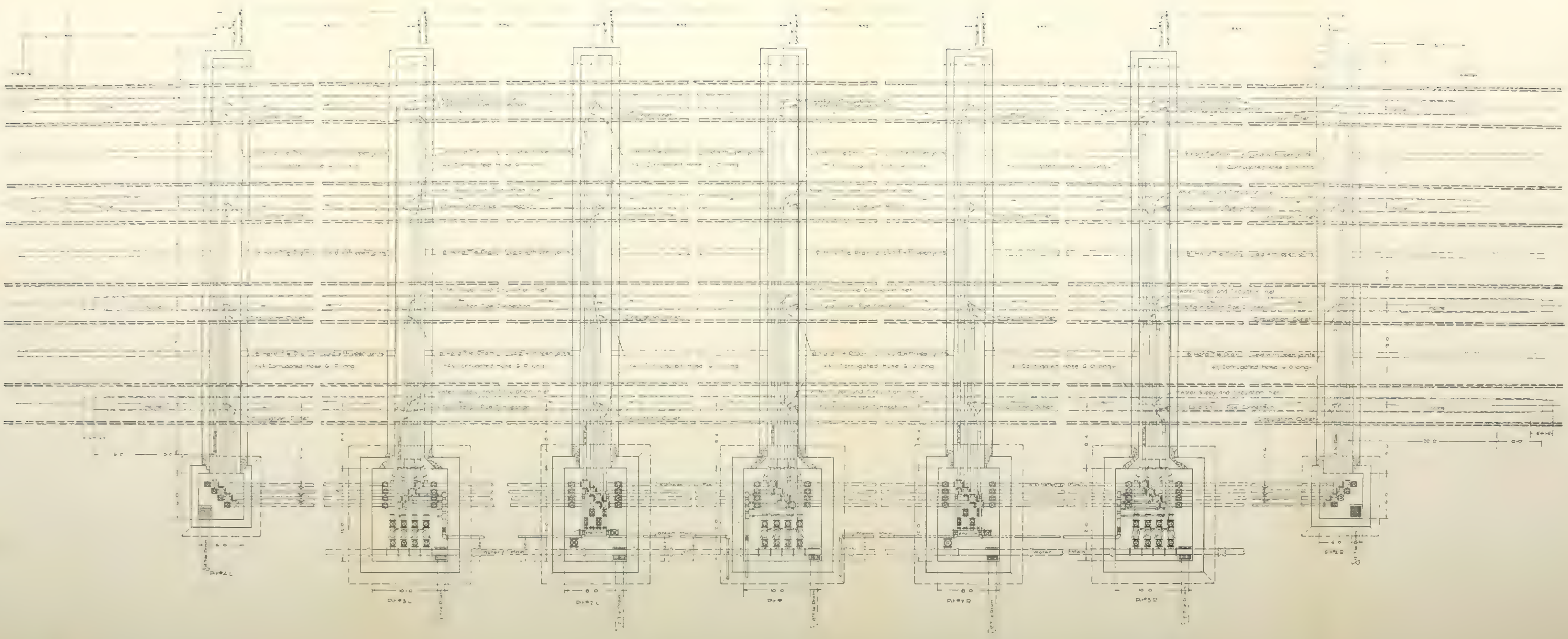


FIG XXI.—CIRCULATION SYSTEM, STANDARD TRACK TROUGHS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY

Fig. XXII

Circulation System, Standard Track Troughs—Lake Shore & Michigan Southern Railway

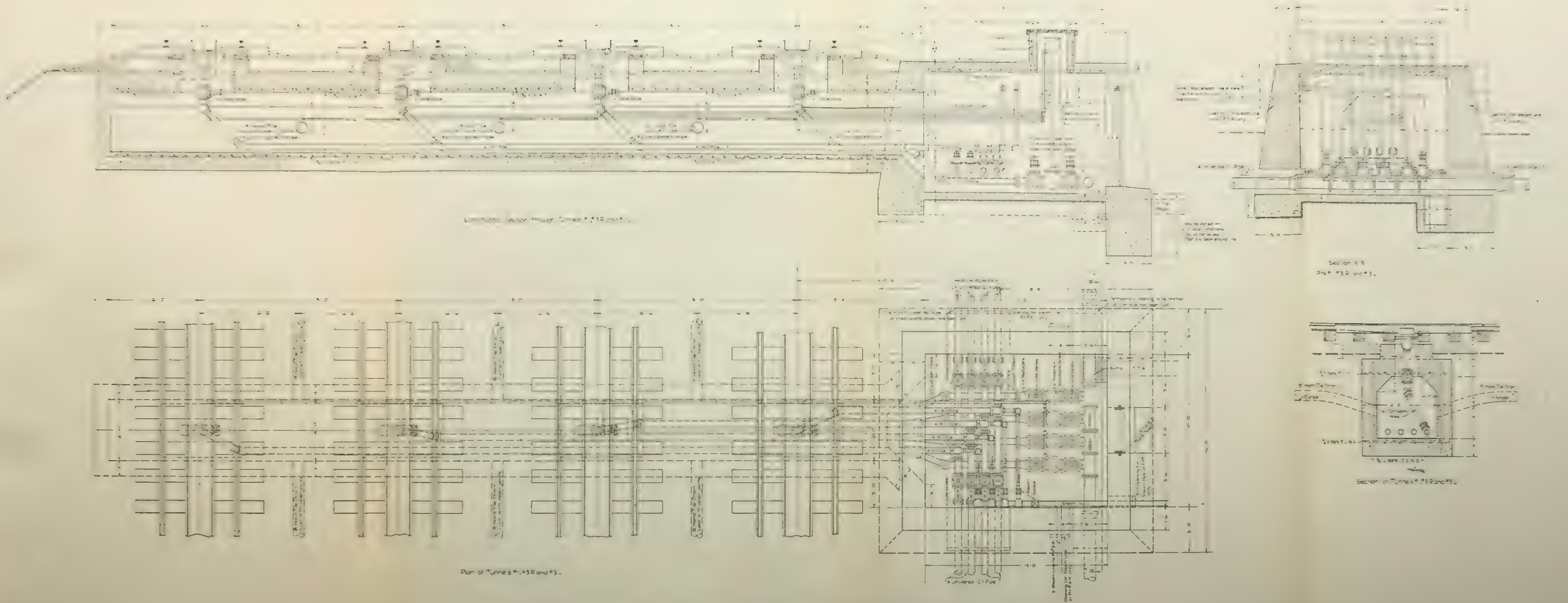
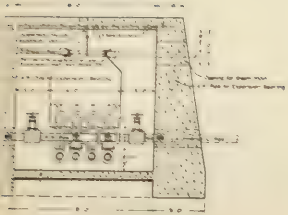

Longitudinal Section Through Tunnels #1, #3R and #3
Section A-B
Pits #1, #3R and #3
Plan of Tunnels #1, #3R and #3
Section of Tunnels #1, #3R and #3

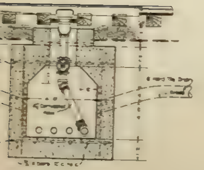
Fig. XXII.—Circulation System, Standard Track Troughs—Lake Shore & Michigan Southern Railway.

FIG. XXIII

CIRCULATION SYSTEM, STANDARD TRACK TROUGHS, LAKE SHORE & MICHIGAN SOUTHERN RAILWAY



Section A A
Pits 28 and 2



Section of Tunnels 28 and 2

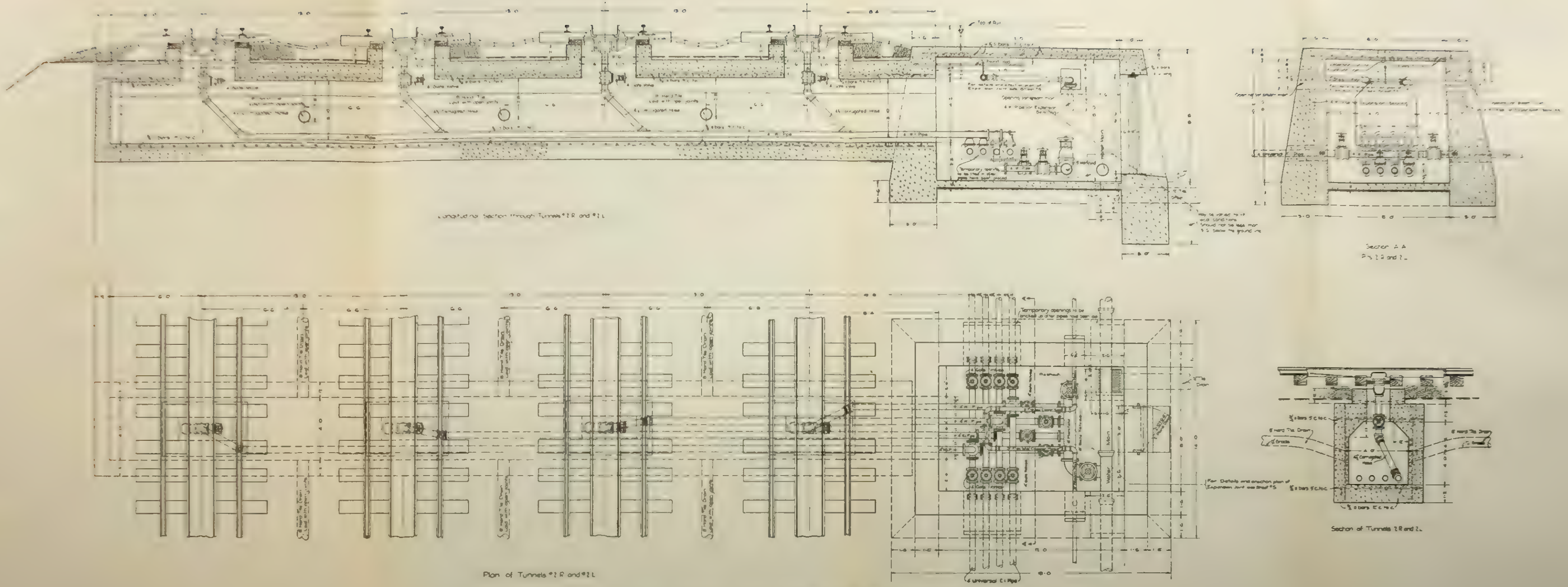

Longitudinal Section through Tunnels #2 R and #2 L
Section A-A
Pits 2 R and 2 L
Plan of Tunnels #2 R and #2 L
Section of Tunnels 2 R and 2 L
Temporary openings to be bricked up after pipes have been laid
4" Universal C.I. Pipe
Main
Water

FIG. XXIII.—CIRCULATION SYSTEM, STANDARD TRACK TROUGHS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

FIG. XXV.

Circulation System, Standard Track Troughs—Lake Shore & Michigan Southern Railway.

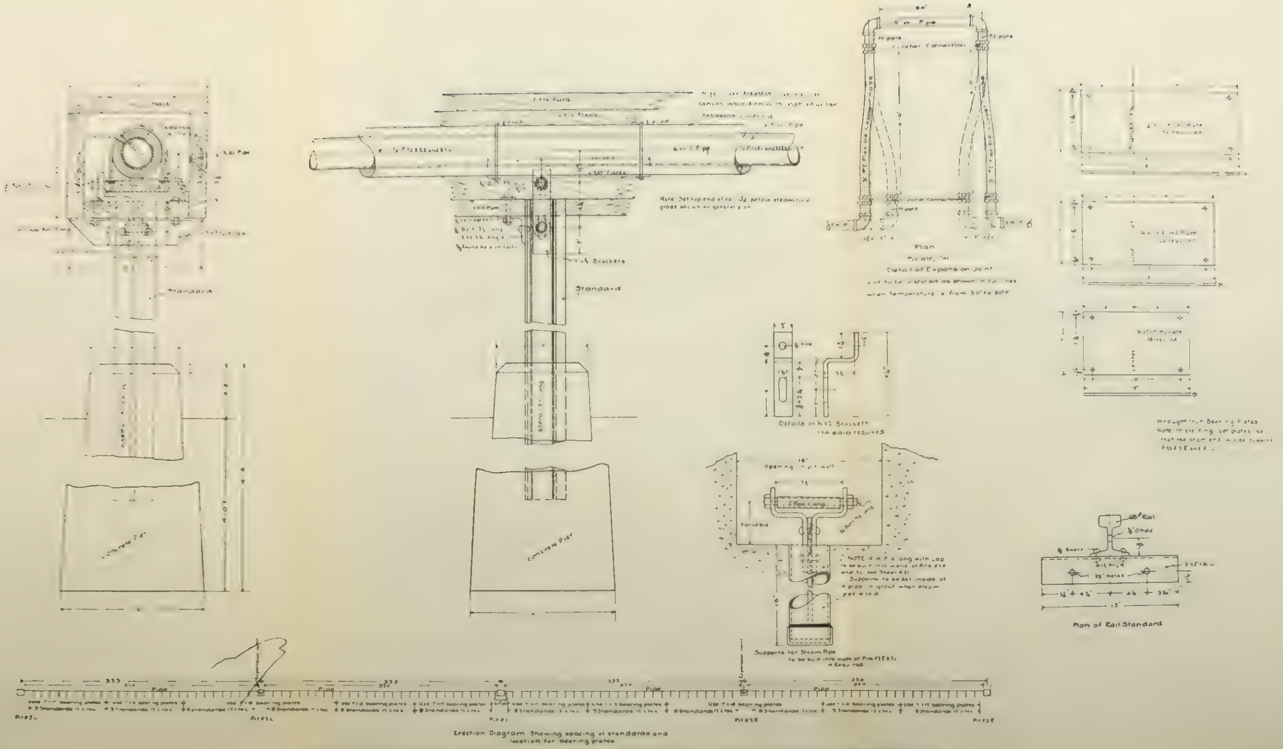

Standard
Standard
T-B Brackets
Concrete Pier
Concrete Pier
Note Set top end of ... below steam line grade shown on general plan
Plan
Scale
Detail of Expansion Joint
Joint to be installed as shown in figures when temperature is from 50° to 80°F
Details of No 2 Brackets
Supports for Steam Pipe
Plan of Rail Standard
13"
Wrought Iron Bearing Plates
Pipe
Erection Diagram Showing spacing of standards and location for bearing plates

FIG XXV.—CIRCULATION SYSTEM, STANDARD TRACK TROUGHS—LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

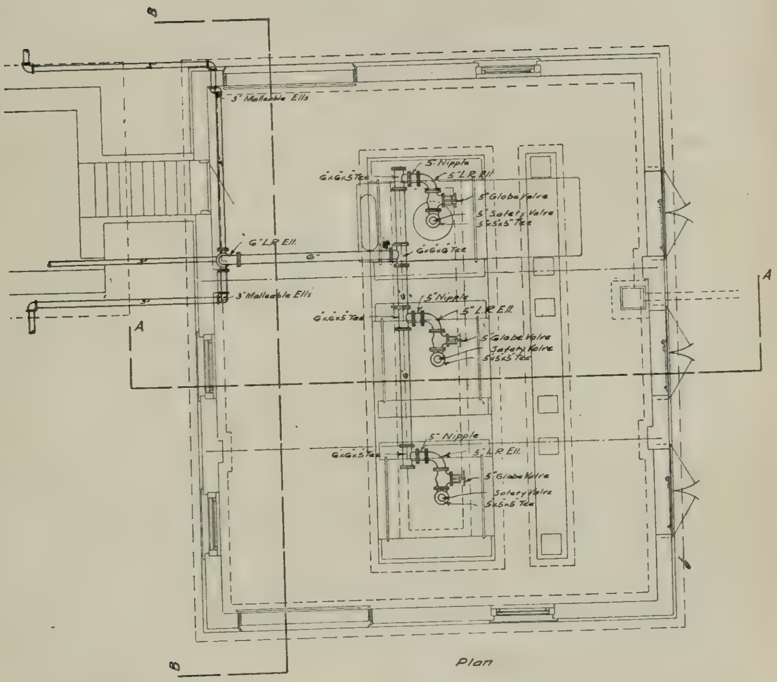


Fig. XXIV.—Steam Pipes for Track Troughs—Lake Shore & Michigan Southern Railway.

Appendix C.

LARGE CAPACITY PUMPING PLANT FOR REGION WITH LIMITED FLOW IN WATER STRATUM;

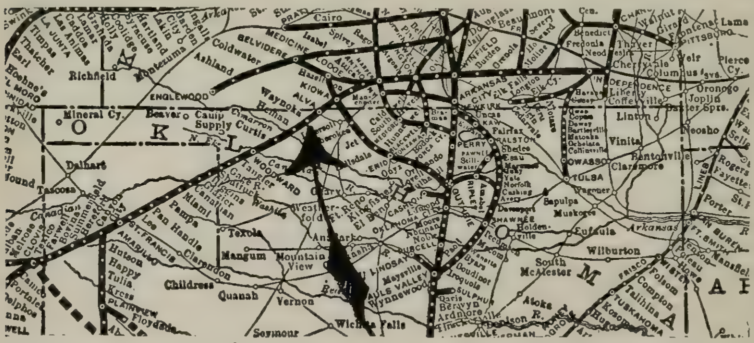
WAYNOKA, OKLA., ATCHISON, TOPEKA & SANTA FE RAILWAY SYSTEM.

(Bulletin 128.)

By C. A. Morse, Chief Engineer System.

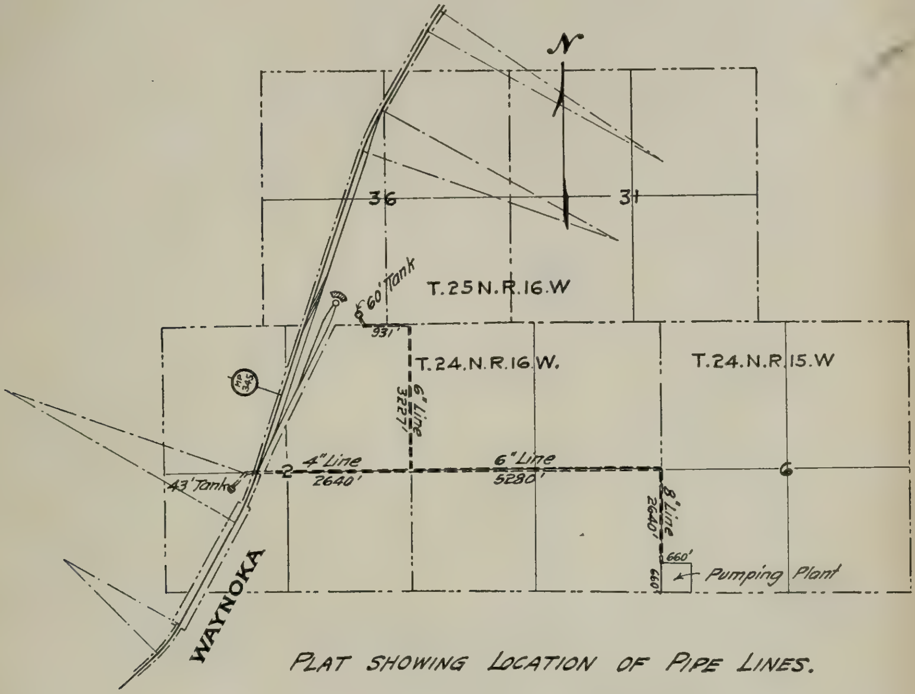
Waynoka, Okla., a division point on the Pan Handle Division of the Atchison, Topeka & Santa Fe Railway, formerly obtained its water from a small creek called Dog Creek. The natural supply from this creek during the dry season was about 40 gallons a minute. After a rain this supply would increase to 60 gallons, sometimes 80, and, of course, during the rainy season the supply was abundant, but the water would then foam badly; but for this, the water was a good boiler water.

Upon making a division point at Waynoka, it became necessary to obtain a larger supply of water which should be as good, if not a better, boiler water. The surroundings of the town of Waynoka were rather peculiar from a water prospector's standpoint. To the north and northwest it was enclosed by red clay hills; to the northeast and the east, by sand hills; and to the south and southwest lay the valley of the Cimarron, with its underflow of very hard water. By drilling it was discovered that the underflow in the town of Waynoka furnished a very poor boiler water.



Driving through the sand hill country to the east, it was observed that there was no surface drainage carrying any of the water away, and that but one creek or arroya had any evidence of being a water course; it therefore occurred to the Supervisor of Water Service, Mr. William Archer, that the rainfall over this area of probably 80 square miles would be found upon the bedrock slowly percolating through the sands and outcropping in the breaks of the Cimarron River.

Numerous samples of water procured from surrounding wells verified this assumption, and steps were taken to secure a small piece of land in the middle of the before-mentioned area (see Fig. B).



PLAT SHOWING LOCATION OF PIPE LINES.

FIG. B.

A tract of land 330 ft. square was selected, a power house built in the center, and eight wells located on the outside boundaries of the tract (see Fig. C). Wells were drilled 8 in. diameter, 50 ft. deep to the bed rock of red clay (see Fig. CC), equipped with working barrels and pump rods and tubing, operated by a central pumping power with lines of shacklerods or cables to each well. The power is operated by a gasoline engine and the discharge from each well is about 32 gallons a minute, or a maximum total of 256 gallons a minute.

As erected, the power house contained two 40 HP. gasoline engines, one intended as a relief. These gasoline engines make 240 revolutions per minute, belted to countershaft running at 230 revolutions per minute.

The countershaft in turn is belted to the central power head, which with its eccentrics operates the eight wells, the head being run about 20 revolutions per minute, making that number of strokes upon each pump.

The countershaft is also belted to two 5-in. rotary pumps set up in duplicate. This rotary takes the water from a cistern (into which each well discharges) and forces it to two steel tanks, one 24 ft. by 60 ft., the other 24 ft. by 42 ft., both two miles away, the railroad receiving its supply from these tanks. The plant is very satisfactory as a whole and it has this advantage—that where the supply from each well is limited in production, the same total supply of water can be increased to an unlimited extent by increasing the number of wells operated by the one power plant.

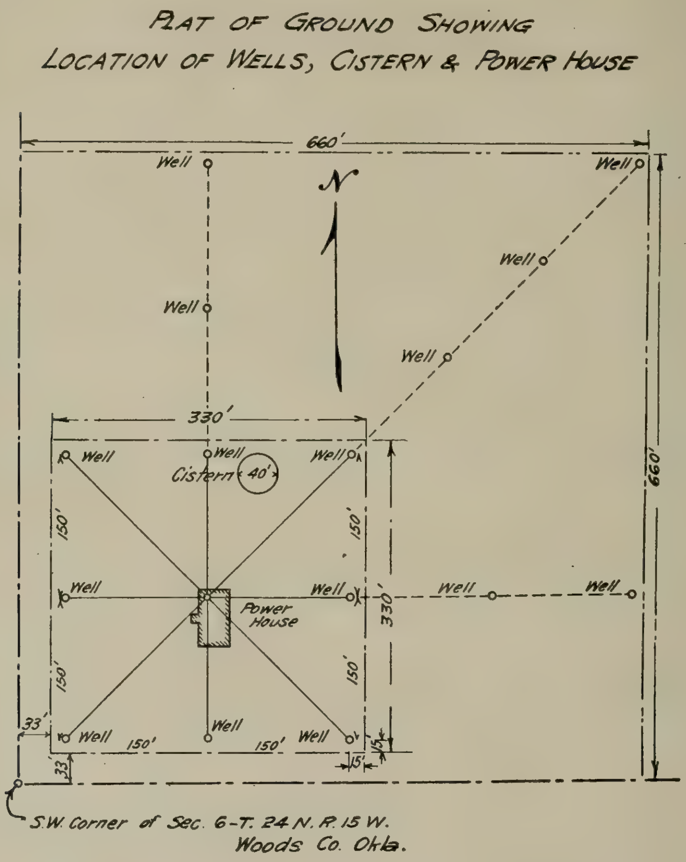

PLAT OF GROUND SHOWING
LOCATION OF WELLS, CISTERN & POWER HOUSE

FIG. C.

Some specific figures as to the size, capacity and cost of operation of this plant may be of interest:

Diameter of working barrel	5¾	in.
Length of working barrel	54	in.
Length of stroke	24	in.
Capacity of cistern	54,000	gal.
Size of the discharge pipes leading from each well direct to cistern (galvanized)	2½	in.
Rotary pumps	5	in.
With suction laid into the cistern	6	in.
Discharge line from the rotaries for the first one-half mile	8	in.
From that point to the tanks at engine house and station	6	in.
Diameter of cistern	30	ft.
Depth of cistern	10	ft.

When the steel tank at engine house is full, the top of the water is 12 ft. higher than the surface of the ground at the pumping station.

The rotary pumps exert a pressure of about 28 lbs. per sq. in., but it has been decided, upon increasing the capacity of the plant, to put in a duplex pump so that, if necessary, a pressure of 140 lbs. per sq. in. can be maintained.

Changes were required in the plant since the original installation, owing to a large increase in business on this division, resultant from making it part of the new through line to the Pacific Coast. The capacity of the plant had to be materially increased, additional land being secured adjacent to the original tract and more wells sunk, operated by extension of the original shacklerods or cables. This change required an additional gasoline power unit.

It should also be stated that the rotary pumps have not been found wholly satisfactory as to capacity, increases in speed beyond a certain point not resulting in a proportionate increase in flow, so that a duplex pump is being substituted, the rotaries being held as relief.

In conclusion it may be stated that a plant such as the one described is admirably adapted for a water district where the underflow is comparatively close to surface, and is not sufficient to provide an adequate supply from a single pumping well. The power consumption is somewhat larger, but the distance of the plant from the railroad line, on account of the greater selection offered for the location of the plant, is likely to be materially less than it would be if a single well were used.

Another advantage is that excellent boiler water may be secured by tapping the underflow in this way rather than by using surface or local river water, although the latter may be much the more abundant.

And lastly, there is the great advantage that the capacity of the plant may be doubled, or even trebled, with but very little increase in the investment, if sufficient land has been secured in the first place.

It is believed that this type of pumping plant, well known in the oil fields, has here been used for the first time for a regular railroad supply and this description is therefore offered for the information of the Association.

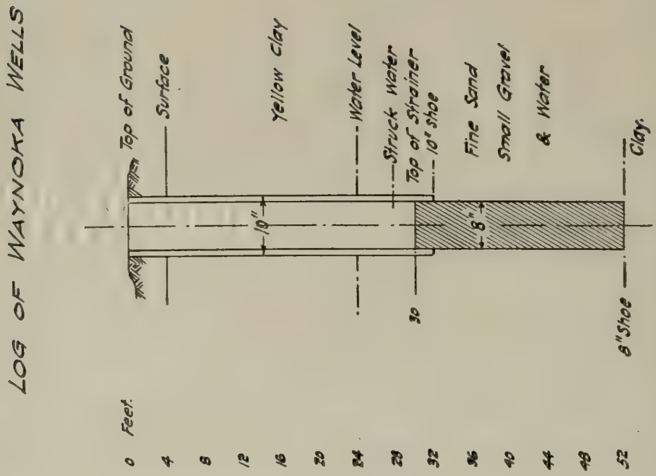

LOG OF WAYNOKA WELLS
Feet.
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Top of Ground Surface
Yellow Clay
Water Level
Struck water
Top of Strainer
10" Shoe
Fine Sand
Small Gravel
& Water
Clay.
10"
8"
30
8" Shoe

FIG. CC.

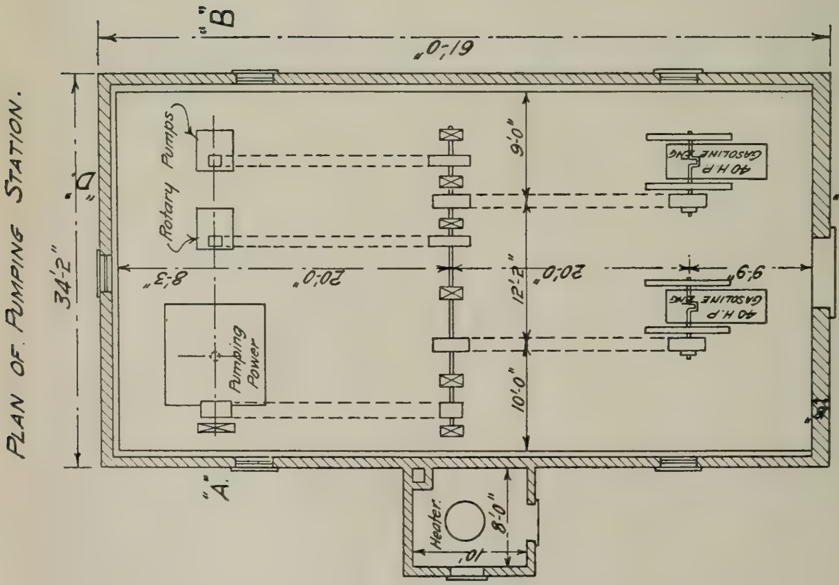
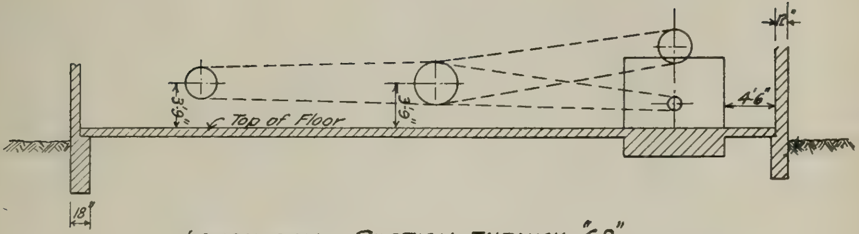
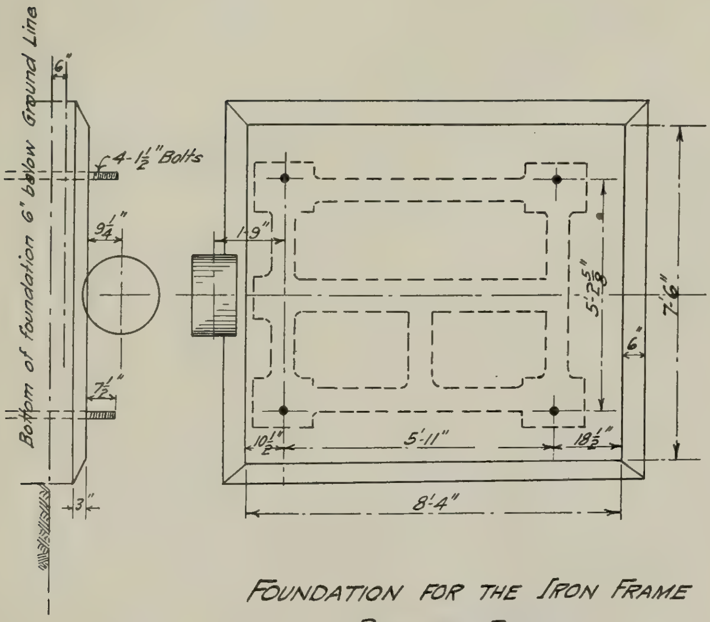

PLAN OF PUMPING STATION.
34'-2"
61'-0"
"A"
"B"
"C"
"D"
Rotary Pumps
Pumping Power
8'-3"
20'-0"
12'-2"
9'-0"
10'-0"
20'-0"
9'-9"
40 H.P. Gasoline Eng.
40 H.P. Gasoline Eng.
Heater.
8'-0"
10'

FIG. D.



LONGITUDINAL SECTION THROUGH "C-D".

FIG. E.



FOUNDATION FOR THE IRON FRAME PUMPING POWER.

FIG. F.

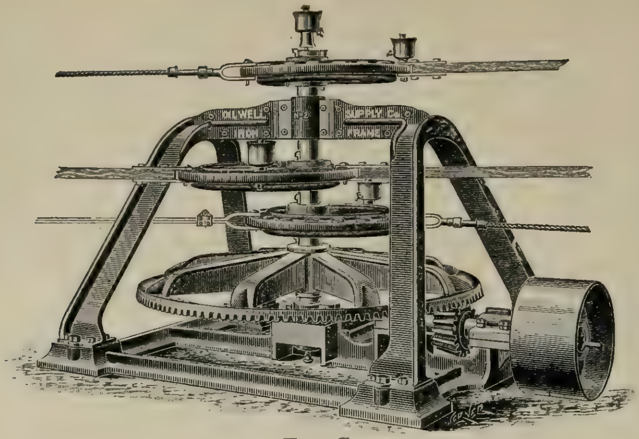
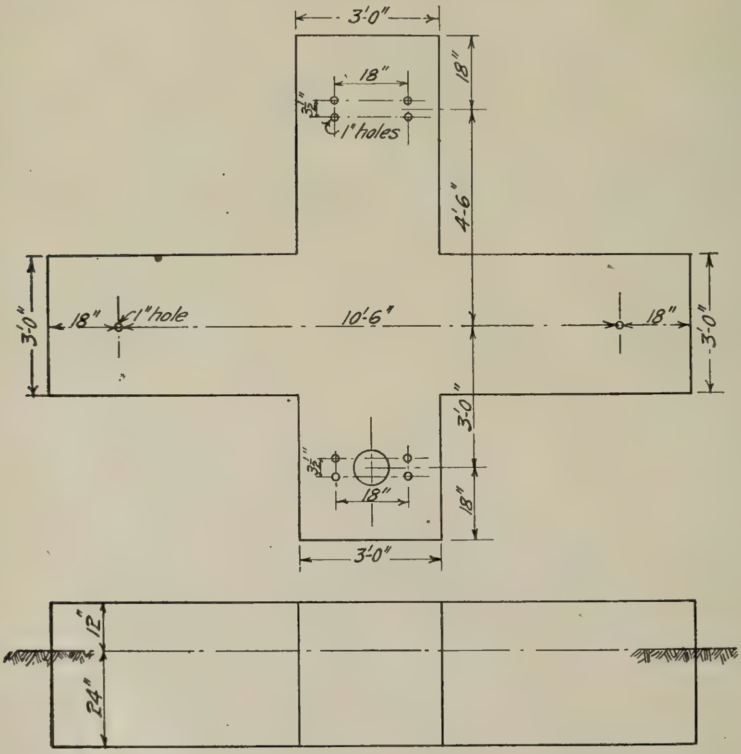


Fig. G.

PLAN OF PUMPING JACK FOUNDATION



ELEVATION

Fig. H.

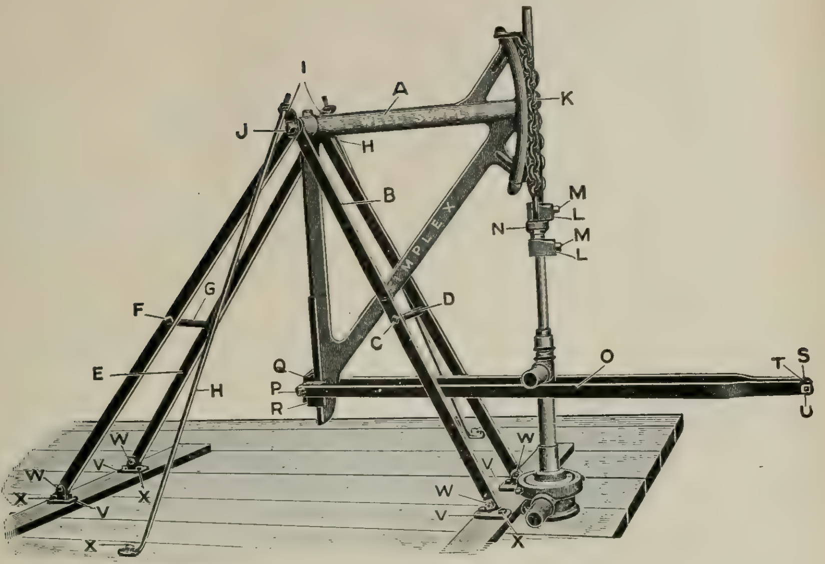
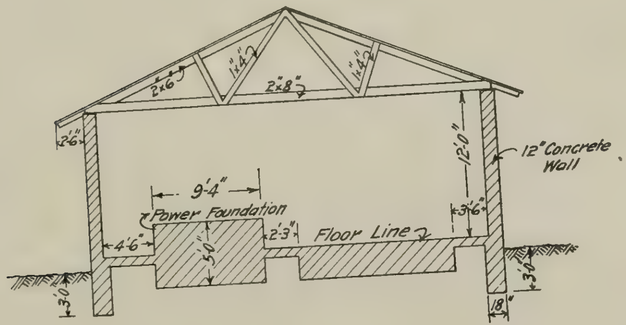
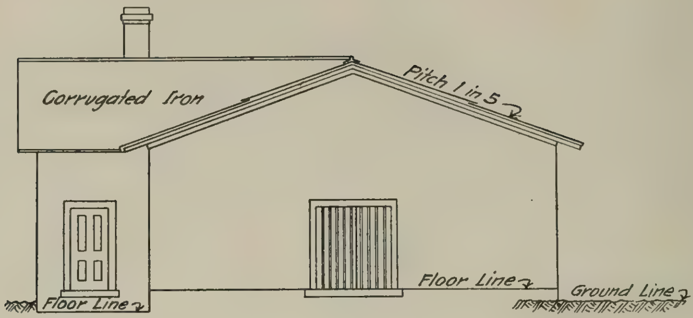


FIG. I.



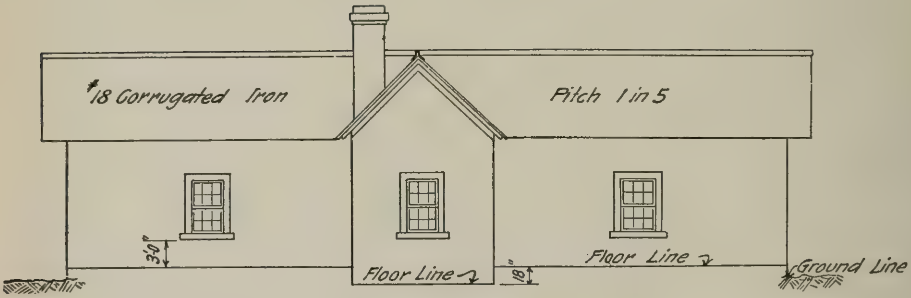
CROSS SECTION THROUGH "A-B"

FIG. J.



SOUTH END ELEVATION

FIG. K.



WEST SIDE ELEVATION

FIG. L.

DISCUSSION.

(The report on Water Service was presented by the Chairman, Mr. C. L. Ransom, Resident Engineer, Chicago & Northwestern Railway.)

Mr. C. L. Ransom:—The report deals principally with water tanks, and there is an interesting appendix submitted on track pans. The Sub-Committee on track pans has done a great deal of hard work on this subject, but inasmuch as this was the first year they had been able to gather any information, the report is simply submitted as an information report. I think the members will find it very interesting.

The conclusions of the Committee will be found on page 92. The first is:

"That the plans and specifications for the reinforced concrete tank be received as information, and the work continued."

This is a new feature in designing, and we did not feel at this time it was good policy to attempt anything more than a progress report on this subject, but the Committee would like the members to present a written discussion on this point, as we feel it is rather too large a subject to discuss in the meeting, and we would prefer to have written discussion from any member who has had any experience in that class of work.

The President:—If there is no objection, conclusion 1 will be accepted.

Mr. Ransom:—The next is conclusion 2, "That the specifications for wooden water tank be approved as submitted, and published in the Manual." In explanation of these designs, I wish to say that at the beginning of this year's work the Committee decided that they would only attempt to analyze two different styles of tanks, one a complete wood substructure and wood tub, and the other complete steel standpipe tubs. We felt that that was all that we would undertake for this year, leaving any other types the Board might desire to analyze for later consideration.

The Secretary:—"Conclusion (3) That the specifications for ordinary iron or steel water tanks be approved as submitted and published in the Manual.

"Conclusion (4) That the specifications for iron or steel water tanks be approved as submitted and published in the Manual.

"Conclusion (5) That the design submitted for wooden water tank be approved as good practice and published in the Manual.

"'Conclusion (6) That the design submitted for metal standpipe type of water tank be approved as good practice and published in the Manual."

The President:—We will take up the specifications in detail on page 78 for wooden water tanks. The Secretary will read the specifications, paragraph by paragraph. If there is no discussion, we will proceed.

The Secretary:—"1. Kind. The tank shall be a wooden tub carried on timber posts supported on concrete piers, as shown on the drawing. These specifications provide for an all-wood structure above the foundation, as shown."

The President:—If there is no discussion, we will proceed.

The Secretary:—"2. Capacity. A diameter of 24 ft. and a height of 16 ft. (outside measurement) are recommended for the tub of this tank. Other dimensions may be used, but the design shall conform to the requirements of these specifications.

"3. Location. The tank is designed to deliver water to locomotives through water columns. The bottom of the tub shall not be less than 20 ft. above the tracks served.

"If water columns are not used, the location of the tank and the necessary tank fixtures shall be as selected by the company.

"4. Loading. Water shall be assumed to weigh 63 lbs. per cu. ft. Wind pressure in pounds acting in any direction on the tub shall be assumed to be thirty times the product of the height by two-thirds of the diameter of the tub. The wind pressure on the substructure shall be assumed at 30 lbs. per sq. ft. of its surface acted on.

"5. Anchorage. Necessary anchorage shall be provided to the foundation on the basis of an empty tub, as the engineer shall design and require."

Mr. J. L. Campbell (El Paso & Southwestern):—I would suggest that it would be better, if we would transpose the phrase, making it read: "Necessary anchorage to the foundation shall be provided."

The President:—That is simply a change in the arrangement of the paragraph. If there is no objection, that will be done.

The Secretary:—"6. Foundation. In earth, the excavation for the piers and frost pit shall be deep enough to permit the pipes to be laid below the frost line, with a minimum depth of 4 ft. In rock, only the excavations for the frost pit and the pipe trenches shall be carried below the action of frost.

"On earth, the total load including wind stress shall not exceed the safe load for that earth. If the earth will not carry this load without material settlement, piling shall be put in as the engineer shall direct. Such piling shall conform to the specifications of this Association for piling, as selected by the engineer. Earth foundations shall be thoroughly tamped to detect and compact any soft places therein."

Mr. F. P. Patenall (Baltimore & Ohio):—I would like to ask if that is not a little error in the wording, "this Association," seeing that these are general specifications? Should it not be the "Maintenance of Way Association," or leave a blank?

Mr. Ransom:—In answer to that, I would say that the last paragraph covers that clause—"this Association"—meaning the "Maintenance of Way Association."

The Secretary:—"7. Piers and frost pit. The piers and frost pit shall be of concrete of a 1-3-5 mix, made and laid according to the specifications of this Association for Portland Cement Concrete and to the forms and dimensions, as shown, including the proper setting of all anchor bolts.

Mr. J. P. Snow (Boston & Maine) :—I object to having concrete so definitely specified. This is to go into the Manual, I understand, and if it is found that a tank was not built according to this requirement, and there was some accident, it seems to me it might get us into trouble. The foundations may be stone masonry, and be made all right. The report says, "the piers and frost pit shall be of concrete." I think that is a bad word to put in the Manual in that connection; it should be "masonry."

The President:—The Committee will accept Mr. Snow's suggestion, and will change that to "masonry."

The Secretary:—"8. Substructure. The substructure shall be constructed, as shown. The timber shall be pine, oak, cypress or redwood, S 4 S for painting, and conforming to the specifications of this Association for No. 1 R. R. bridge timber. It shall be accurately framed and erected, properly tightening all bolts and tie rods."

"9. Rods and bolts. All rods and bolts shall be iron or steel of the quality hereinafter specified for tank hoops. O. G. washers shall be used under heads and nuts of bolts and tie rods."

"10. Tub: quality of lumber. The tub shall be made of pine, cypress or redwood, sound, seasoned, out of wind, free from shakes, sap, pitch pockets or streaks, unsound knots, loose knots, knots in clusters, and large knots extending through the material. Small, loose or unsound knots may be bored out if the holes are thoroughly plugged. Material having knots in its edges will not be accepted."

Mr. F. S. Stevens (Philadelphia & Reading) :—I think that the comma, after "small," should be eliminated, so that it would read, "small loose or unsound knots."

Mr. J. L. Campbell:—It is the intention of these specifications to distinguish between small knots and loose knots.

Mr. H. A. Lloyd (Erie) :—The specification for the kind of wood is a little too general. The family of pine is very large, and in using Norway pine, you might get bad results. It simply states "pine." If it is to be as general as that, it seems to me the species should be stricken out, and just say, "made of wood."

Mr. J. L. Campbell:—In the word "pine" the Committee intended to include any wood that would properly come under that general class of timber, and that would include yellow pine, white pine, Douglas fir, and possibly other classes of pine that would be found entirely suitable for the work.

Mr. Lloyd:—That would seem to include Norway pine to the uninitiated.

Mr. G. D. Brooke (Baltimore & Ohio) :—I agree with Mr. Stevens in regard to the punctuation in the next to the last sentence. I hardly think it is the intention of the Committee that a large loose knot shall be bored out, and the hole plugged. As the sentence now reads, it would convey that impression.

Mr. Ransom:—A large loose knot would be considered unsound, I think.

Mr. W. H. Courtenay (Louisville & Nashville):—It seems to me it would be better to omit the comma. I am of the opinion it would be a bad plan to bore out a large loose knot, and plug it.

The President:—The Committee will accept that.

Mr. C. H. Stein (Central of New Jersey):—In reference to the first line of the specification, I agree with the gentleman who spoke a while ago, who stated that there should be something more specific in regard to the kind of pine. The pine family is a very large one. If we place a specification like that proposed in the hands of the contractor, he might make a tank out of some species of pine that would be very objectionable. I would also ask, by way of information, whether any kind of cypress would be suitable for a water tank?

Mr. Ransom:—Quite a number of Southern firms are making tanks out of cypress, and many Southern roads are using them.

Mr. Stein:—Any kind of cypress?

Mr. Ransom:—The Committee would be glad to have suggestions as to changing this reading so that it could be made plainer. The timber family is so various, that it is pretty difficult to make a specification that is going to cover all of the different timbers that are grown in the United States, and the Committee would be glad to have suggestions on this subject.

Mr. A. K. Shurtleff (Chicago, Rock Island & Pacific):—I hardly believe any company would let a contract as broad as this, and leave it to the contractor as to what wood was to be selected. My suggestion is that this be left blank, to be filled in by the company, selecting the wood they desire the tank to be made of. The specification should be specific.

Mr. J. L. Campbell:—This Committee last year brought in a specification for tanks full of blanks, and the Association objected. The Association wanted the blanks filled in, and in doing that, we recognized that we would get into trouble. The point you make here is one that we will come to in a little while, and the trouble will be on the other side of the fence. I think the criticism that may possibly arise in connection with these specifications is that we have been too specific. The idea in the preparation of the specification was to cover the quality of the wood—to make it as general as the Committee thought permissible, and then specify the quality. Still, it is true that it says "pine," and that would admit any kind of pine. The specification says it should be sound and seasoned. I believe it is the opinion of the Committee that any sound and seasoned wood would be durable, provided it was kept saturated.

Mr. A. F. Robinson (Santa Fe):—I would like to suggest that you make that first line read, "the tub shall be made of suitable pine" or, "the tub shall be made of acceptable pine."

The President:—The Committee will accept that.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—I should like to see the specifications changed so as to include cedar for staves and fir for bottoms.

The President:—The Committee will accept that.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I think the way in which the matter has been disposed of is entirely satisfactory and the best thing that can be done. If you undertake to specify any particular kind of pine, I would suggest long leaf yellow pine, to have not less than eight rings to the inch, and I would include white pine and red and yellow cypress, but these matters should be left to the parties who are able to command that kind of material.

Mr. Ransom:—I think the paragraph as amended, "acceptable pine," will cover the situation.

The Secretary:—"11. Tub bottom. The bottom of the tub shall be made of 3-in. planks, S 4 S, and accurately cut and planed to uniform thickness and width. The ends shall be cut to the true circle of and shall fill the croze in the staves. Each plank shall be in one piece without joint or splice. The planks shall be joined by ¾-in. by 3-in. wood dowels on 30-in. centers along each joint. The bottom shall be laid directly on the floor joists."

Mr. J. L. Campbell:—I suggest we add to the sentence in regard to the length of plank, these words, "for all tanks having a diameter not greater than 24 ft." The sentence will then read, "Each plank shall be in one piece, without joint or splice, for all tanks having a diameter not greater than 24 ft." There might be difficulty in securing planks longer than that.

The President:—The Committee will accept that suggestion.

The Secretary:—"12. Tub staves. The staves shall be of uniform width, end to end, and shall be made of 3-in. planks, S 4 S, with edges accurately planed on radial lines from center of tub. Each stave shall be in one piece, without joints or splice. The croze in each stave shall be accurately cut to uniform dimensions on one circle for all staves. The croze shall be 3 in. in the clear from the end of the stave."

The President:—The Chairman suggests that the word "each" be substituted for the word "the" in the first line.

Mr. Walter Loring Webb (Consulting Engineer):—I notice in the specification that the staves shall be of uniform width from end to end, etc. That practically limits these tubs to the cylindrical style rather than the conical. Is it the intention to cut out the use of conical tubs?

Mr. Ransom:—Yes.

Mr. Walter Loring Webb:—I would like to ask if that is not a distinct departure from common practice, and if so, has the Committee decided that that departure is necessary?

Mr. Ransom:—It is a departure from common practice of twenty years ago, but not a departure from modern practice. I think there are very few railroads at the present time that are building conical tubs.

Mr. O. E. Selby (Cleveland, Cincinnati, Chicago & St. Louis):—I see nothing in the specification to limit the width of the staves. The tendency of the manufacturers is to make the staves as wide as they consistently can, because it makes the job cheaper, and I suggest that a limiting width of 10 in. be inserted.

Mr. Ransom:—I think there is not much trouble to be anticipated on that score—it is difficult to get lumber of this quality that is wider than 8 in. at the present time. The quality of the timber would govern the extreme and minimum width of the stave. That could be left to the railroad company to specify in the contract.

Mr. Selby:—I think there is likely to be difficulty, and, in fact, we have so found it. We have found where the width is not limited, the manufacturers will put in staves up to 10 and 11 in. wide, and they do not give satisfactory service. It is not hard to get timber of the quality demanded in fir and yellow pine, and even in cypress, up to widths of 12 in. or more.

Mr. A. F. Robinson:—As soon as you get away from a timber 10 in. wide, there is an increased cost per thousand feet, board measure, and I do not think we need to worry about the manufacturers putting in many 12 in. planks, when they can use 10 in. at two dollars per thousand feet, board measure, less cost.

Mr. C. E. Lindsay (New York Central & Hudson River):—I am not sure but the point raised by Prof. Webb is a very vital one. While it may be true that the conical tub is a thing of the past, many railroads are still using them, and a conical tub has the merit of taking advantage of the force of gravity in keeping the hoops from falling off entirely in the event of shrinkage, and I, for one, would like to endorse the conical tub.

Mr. W. M. Camp (Railway and Engineering Review):—The same question was up before the Association of Railway Superintendents of Bridges and Buildings, last October, and the sentiment expressed in the discussion there seemed to conform to the Committee's report, namely, that cylindrical tubs are now preferable, since adjustable hoops have come into service. In former years, when solid hoops were used and had to be driven on, of course it was necessary to have the conical-shaped tub.

Mr. Ransom:—I will say for the benefit of the Association it was either one or two years ago that the Committee was badly censured on the floor of the convention for permitting the conical tub to be mentioned in the specifications.

The Secretary:—"13. Tub hoops. The tub hoops shall be half oval, half round, or round. They shall preferably be made of wrought-iron. They may be made of steel.

"Wrought-iron shall be made of pure puddled iron having a tensile strength of 50,000 lbs. and containing of

Sulphur	not	more	than	.02	per cent.
Phosphorus	"	"	"	.005	"
Carbon	"	"	"	.02	"
Manganese	"	"	"	.00	"
Silicon	"	"	"	.00	"

"Steel shall conform in physical and chemical properties to the specifications of this Association for steel bridges.

"Each hoop shall be in three equal sections."

Mr. Brooke:—I suggest that the last paragraph of that section reading, "Each hoop shall be in three equal sections," be combined with the first section of the first paragraph, which would then read, "The tub hoops shall be half oval, half round, or round, and shall be in three equal sections."

Mr. J. L. Campbell:—In connection with that, there has been some question raised as to the advisability of having three joints in the hoop. That is well taken in the tank 24 ft. in diameter. I suggest we change it to read, "Each hoop shall be in not more than three sections," and we will accept the suggestion and change the specification.

Mr. W. H. Courtenay (Louisville & Nashville):—If this Association is to go on record as abandoning the flat hoop, I think it would be desirable that it should go the whole length, and go to the round hoop. I am not able to see the advantage of a half-oval or half-round hoop as against a round hoop. The round has the simpler form of the three—it is generally easier to get, and I am unable to see any advantage which the half-round has over the round. I think to some extent the half-round would offer some of the disadvantages of the flat hoop, that is, it would rust speedily on the flat side in contact with the tub. That has been the overwhelming objection to the flat hoop. I have known of many cases of failures of the flat hoop, where the outside of the hoop appeared to be sound. If we are to change to some form of approximately round, it seems to me it would be better to adopt the round and leave out the half-oval and half-round.

Mr. J. L. Campbell:—That brings up again the difficulty that we have in preparing specifications. There is the objection to making one specification for round hoop that shall limit the recommendation to one thing. The Committee believes the half-oval or half-round hoop is a good hoop, a decided improvement over the flat hoop, on account of the greater concentration of the metal, and smaller surface exposed to corrosion, and in the preparation of the specifications the Committee endeavored to avoid mentioning any one specific article, where we could avoid doing so, particularly where other equally good forms could be included.

Mr. Snow:—I object seriously to limiting the hoops to round ones, on account of the trouble arising from dust and dirt collecting above them, in which moisture is retained on the outside of the stave. It might be supposed that you could keep this space filled with paint, but the hoop will drop away from the paint, and you will have a groove there and it will rot the stave.

Mr. Lindsay:—I am grateful to the Committee for making the change in the specification, which does not permit us to use more than three sections in the hoop. I was afraid that after a while we might get a chain around the tank instead of a hoop. Is there anything about the round hoop or oval hoop that requires three adjusting points? We have been able to maintain tanks successfully and economically with one adjustment, both on round hoops and flat hoops. Why three?

The President:—The Committee has changed that to read, "Not more than three."

Mr. Lindsay:—I understand that. I am asking for information.

Mr. Ransom:—The only object in having a large number of joints is that we believe the tension can be more evenly distributed on the staves, and get a tighter and better tank.

Mr. George W. Kittredge (New York Central & Hudson River):—I do not like to see flat hoops ruled out altogether. It is entirely possible that by getting a proper quality of metal, either pure iron, or something that approaches it, that we can get flat hoops that will give good service. These specifications should be broad and cover all good practice. I thoroughly agree that if the hoop was to be made of steel, the flat hoops would probably be better ruled out, but I do not like to see them ruled out under all conditions. The specifications should provide in some way for flat hoops.

Mr. C. E. Smith (Missouri Pacific):—I would like to know if any members of the Association have had experience in the use of flat hoops of a sufficient thickness to indicate what would happen if a thick hoop were used. It seems to me the flat hoops have been condemned on account of failures that have occurred in hoops ⅛ in. and $\frac{3}{16}$ in. in thickness, and if a hoop not less than ½ in. thick were used, or even thicker, we might not have those failures. I would like to know if the members have had any experience in the use of thick, flat hoops?

Mr. Courtenay:—I will state, for the benefit of the gentleman, that we have used square hoops. One objection to a square hoop is, in putting it on, it is hard to keep it from turning, so that one of the corners cuts into the wood. I have seen square hoops applied, and there was a whole gang of men trying to keep them from twisting, to prevent a corner of the square from coming in contact with and cutting into the staves. We have round hoops on a tank that has been in since 1886. Our experience has been that staves do not rot any more quickly where in contact with round hoops than at other places. We adopted, some years ago, the standard of flat hoops and thought perhaps that the round hoops would cut into the stave. We had trouble with tanks falling down on account of flat hoops rusting on the side next to the tub, when the side exposed to view was apparently good, and giving no warning. The round hoop is better because of the splice which can be made with it. It is a difficult proposition to make a good joint with a wide, thin, flat hoop. It can be riveted to lugs, or put on same with friction joints. I have had tests made with several forms of friction joints in different ways, and none of them that were tested developed the strength of the hoop. It is an easy matter to make a good connection with a round hoop, of one section with another of the hoop.

Mr. Ransom:—The Committee would like to quote from correspondence which we have had from the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, who have made a specification for wooden tanks for use on tops of buildings in connection with fire protection. I would like to quote this paragraph:

"The strength of a tank depends chiefly on its hoops. Experience shows that flat hoops, especially those of steel, rust from the back side, where they bear against the staves, and serious accidents have happened by hoops bursting on account of this unobserved corrosion. Sometimes galvanizing or painting is depended upon to prevent rusting, but there is always the possibility that spots of the protective coating will be knocked off in handling, and one spot left unprotected may result in the failure of the hoop. Round hoops are, therefore, advised for all tanks, since for a given cross-section of metal, these hoops have the advantage of presenting the least surface to corrosion. Nearly the whole surface can, moreover, be examined or painted while the hoops are in place. In setting up a tank with round hoops there is little probability of tightening the hoops to such an extent that when the tank swells the hoops will burst; for the round hoops will simply indent the wood more as the tank swells, and the strain in the hoops is not likely to be increased to the breaking point."

I will say that this Association recommends round hoops and round hoops only.

Mr. Kittredge:—If the Committee does not see fit to modify the specifications so as to permit the use of flat hoops, I would make a motion that this article be so modified that it will permit of flat hoops.

Mr. Selby:—Answering Mr. Smith's inquiry a few moments ago in regard to the use of thick, flat hoops, I will say our road has had experience with thick, flat hoops, about twice the thickness of the average manufacturer's standard, running from a quarter in. to three-eighths in., and in width from 4 in. up to 6 in. Of course, these hoops are stronger, and last longer, resist corrosion longer than the thin hoops ordinarily used, but we have abandoned them for round hoops. Mr. Kittredge suggests that the objection to flat hoops may be overcome by the use of some rust-resisting metal, ingot iron or some material of that kind, but the rapid corrosion is only one of the objections to flat hoops; the other is the difficulty in making proper connection with the lug, and the unsatisfactory performance of the connections after they are installed. There is a tendency to pull the hoop away from the tub at the heel of the lug. The connection to the lug is necessarily eccentric, and the pull on the drawbolts tends to pull the hoop away, and bend it immediately at the heel of the lug. This makes a weak point in the hoop, and makes a point where decay can start in the staves under the hoop.

I recall that either one or two years ago this Committee brought in a report specifying flat hoops exclusively and it was turned down.

The President:—Wrought-iron.

Mr. Selby:—Now they have made a report excluding flat hoops, and specifying round, half-round or oval, and that is such a step in advance that I am sorry Mr. Courtenay raised the question of excluding the half-round and oval and limiting it to round hoops. We ought to be so well satisfied to get away from flat hoops as to be willing to accept several other forms.

Mr. Robert Ferriday (Cleveland, Cincinnati, Chicago & St. Louis) :—Last year we showed the flat hoops and quite a number of the members of the Association got up and said they were all using the round hoops. Our recommendations last year had been based upon reports received from a circular which showed a very large percentage using flat hoops, and that is the reason we brought it in. The only explanation we could find of the change in opinion was that the answers to our circular had been made from old standard plans, without the personal supervision of the members of the Association themselves; and that is the reason we dropped the flat hoop this year, on account of the very general preference for the round hoop.

Mr. Kittredge :—I was the person, I believe, referred to a few moments ago as the man who objected to flat hoops exclusively a year or two ago. I object just as much to-day to the round hoops or oval hoops exclusively as I did to flat hoops exclusively at that time. Personally I am a round-hoop man, but I do not want to see specifications of this Association, which are spread broadcast, not only over this country, but other countries, go out leaving out of consideration flat hoops. The design and structure of a flat hoop, I am sure, can be so worked out that it will be efficacious. I have known flat hoops to last the life of a tank—thirty years—and I am quite a believer in what has been done can be done again. If the flat hoops are put in, that clause which says they may be made of steel will have to be modified. I want to support my motion that the flat hoops be included. There are a very large number of flat hoops in use in this country, and we do not want it to be understood that there are no good flat hoops.

Mr. F. S. Stevens :—In relation to the suggestion of Mr. Kittredge, that flat hoops might be protected on the back side by a non-corrosive material or compound, I would like to state that I have known flat hoops ⅜ in. thick, protected by two coats of red lead, and placed on the painted surface of the tub, to be corroded through and burst off in less than eight years.

Mr. Lindsay :—I am in favor of the motion, and heartily support it, and I would like to ask if the Committee will accept an addition to the specification, as follows: "Flat hoops of approved design and material may be used."

The President :—The Committee is unwilling to accept that, Mr. Lindsay.

Mr. Lindsay :—Will Mr. Kittredge include that in his motion?

Mr. Kittredge :—Provided that edits all right, I will accept that amendment.

Mr. F. H. Falkinburg (Baltimore & Ohio) :—Before putting this to a vote I would like to mention a small factor which we found in our experience in favor of the round hoop; that is, that the spaces at the bottom of the tub, between the hoops, using the round hoops, being greater than the width of the hoops, it is possible to renew the hoops on a tank already in use, by beginning at the bottom, which it is impossible to do where flat hoops are used, on account of flat hoops being wider than the spaces between them.

Mr. McDonald:—Mr. Kittredge has stated that we ought not to send these specifications broadcast, limiting the use to any particular thing. I think the province and object of our Association is to find out what is the best thing, and notwithstanding the fact that I recall an instance of one red cedar tub that has stood forty years with flat hoops, I recall a great many other instances where flat hoops have failed that have been on only seven or eight years, and I think we ought to go on record as favoring round hoops; but I am afraid this specification giving the chemical analysis is probably framed in such a way that the product would be confined to one or two manufacturers.

The President:—Mr. Loweth, we would like to hear from you on this subject.

Mr. Loweth:—Although it has been the practice of the St. Paul road for some time in the past to use round hoops exclusively, I do not think that this Association ought to commit itself exclusively to round hoops. The Committee has evidently taken a great deal of pains in making its report, which is in many ways an admirable one, but in some ways I think it has put the cart before the horse. I think it would have been much better if the report had summed up the advantages and disadvantages of the various practices in the design and construction of tanks, so that this Association might have had all the information pertaining to flat hoops, round hoops, iron hoops and steel hoops, and the other details that enter into tank construction. This convention could have profitably discussed a report containing such information. But now the Committee is asking that this Association adopt the specifications it submits, and because they vary largely from current practice. it puts a great many on the floor of this convention on the defensive and tends to make the discussion acrimonious. This would not be the case if the specifications were to be accepted as information and not adopted. It seems to me that this body of men can very readily make their own specifications for such structures as tanks, especially if furnished with information as to the relative merits of various details of design. I believe that our committees should confine themselves more to the gathering of information and compiling it, and not in formulating hard and fast specifications as to best practice. Only infrequently will it be desirable to agree on specifications and uniformity of practice in design and construction, and it will be still less frequently desirable, in my judgment, for this Association to adopt the specifications and conclusions as to practice contained in the committees' reports. These remarks apply not only to the work of this Committee, but as a general proposition to that of many others.

(Mr. Kittredge's motion was lost.)

Mr. Snow:—I wonder if the Committee will agree to omit the chemical specifications for iron? It is impossible to obtain it except, as Mr. McDonald says, from one or two concerns, perhaps.

The report specifies "puddled wrought-iron" and then prescribes a chemistry that, in my opinion, cannot be met by the puddling process.

There are three kinds of wrought-iron, viz., puddled, fagot and ingot. Puddled iron contains slag, which is partly eliminated in the process of rolling, but the best refined iron made in the puddling furnace will carry some silicon.

Fagot iron is made by piling and rerolling. It generally contains much scrap and may be wholly scrap. That made at present is almost certain to contain more or less steel scrap and will rust as readily as any iron.

Ingot iron is made by turning into molds and rolling without piling. The chemistry proposed by the Committee can be reached by this process.

All three of these irons can be wrought freely. But if the iron of thirty years ago is wanted, it must be puddled iron; and the chemistry had best be omitted. A better specification would be: "puddled iron, double rolled from the muck bar." This means, cutting and piling the muck bars, reheating and rolling them and cutting and piling the resulting bars and reheating and rolling them to the desired shape.

Mr. Ransom:—The Committee is not willing to accept that, inasmuch as iron of this character can be purchased at the present time.

Mr. Courtenay:—Will the Committee please state the manufacturers of that quality of iron? As a matter of information, I would like the Committee to inform the Association who does manufacture this quality of iron.

Mr. Ransom:—The American Rolling Mill Company, Middletown, Ohio.

Mr. Courtenay:—So-called ingot iron?

Mr. Ransom:—Yes, sir.

Mr. G. H. Tinker (New York, Chicago & St. Louis):—I would like to say that there are a number of mills that manufacture that quality of iron.

Mr. J. L. Campbell:—It seems that it is entirely practicable to produce this quality of iron, and if the Association calls for that quality, we will get it. I fail to see the force of the objection to including this specification for iron in these specifications, provided the specification itself is all right.

Mr. Brooke:—I would like to state that the Baltimore & Ohio Railroad purchased a number of tanks last spring, and had no great difficulty in getting wrought-iron hoops.

The President:—If there is no further discussion or motion to change clause 13, we will proceed.

The Secretary:—"14. Hoop coating. Each hoop shall be cleaned (preferably at the factory) of dirt, rust and scale, and in that condition shall be heated to 300 degrees Fahrenheit and be dipped in pure asphalt having that temperature, which shall be maintained during the immersion, which shall continue not less than one minute."

Mr. Loweth:—Why is asphaltum better than paint for tank hoops? It is less readily obtained and much harder to apply in the manner specified, and I am not satisfied that it will preserve the hoops any longer.

Mr. J. L. Campbell:—I think that probably the specification might be improved in that particular. I believe the Committee is not wedded to asphaltum. I think coal-tar might be all right, and there are paints which might be good substitutes for the material specified here.

Mr. Maurice Coburn (Vandalia):—Speaking about pure asphalt, the nomenclature of asphalt is a rather indefinite matter. Commercial pure asphalt, as I understand it, is an asphalt fluxed with a considerable portion of oil. The term as used is liable to be misleading and indefinite.

Mr. Ransom:—The Committee would accept the suggestion and add a sentence to the paragraph saying, "or such other coating as the engineer shall approve," leaving it open to coat the hoop in any manner the engineer sees fit. The only object was to be sure that the hoops are coated with some protective coating before they are put on the tank.

The President:—Does that meet your objection, Mr. Loweth?

Mr. Loweth:—To add the clause as proposed would leave it to be inferred that asphalt coating was preferable to paint. Iron and steel structures are painted, and seldom, if ever, coated with hot asphaltum, and if paint is good for these, why not for the iron hoops on a tank? The clause ought to be so amended as to put the use of paint at least on an equal basis with an asphalt coating.

Mr. J. L. Campbell:—It has been my experience that the coating that adheres more closely to the iron is the coating that is placed there when both the material and the iron are hot. I have found that in heating the steel and immersing it in a bath of asphalt, it gives a coating that adheres tenaciously to the material, and in that way I believe it is much superior to applying cold paint to cold iron.

Mr. W. F. Steffens (Boston & Albany):—Mr. Loweth's question raises the old paint discussion, as to the lasting qualities of coatings. In the case of bridges or other structures, the surfaces are accessible for painting, but in the case of hoops, as Mr. McDonald recently attested, one tank had stood forty years without painting. I would like to find any linseed oil paint that will stand up forty years behind a hoop, where it is inaccessible, even if protected from the air. The moisture conditions, due to the hoop being in contact with the wood, which is to a large extent porous, must eventually break down the linoxyn formed from the linseed oil, which is an unstable and vulnerable compound. On the other hand, the asphaltum coatings recommended by the Committee have been known to stand, under such circumstances, over forty years where they have not been in contact with sunshine and open air. Personally, I hope the recommendation of the Committee will stand as to the asphaltum coating, and that we will not permit the linseed oil paints to be introduced.

Mr. Coburn:—I would suggest, instead of using "pure asphalt," we say a "good asphalt paint."

The President:—The Committee suggest that would be indefinite.

Mr. Lindsay:—This Association will be placed in an equivocal position if it does not look out. The Committee on Buildings says that asphalt and water is not a good combination. We are recommending here pure asphalt in connection with a water tank.

Mr. Coburn:—An asphalt coating would be good.

Mr. Steffens:—If Mr. Lindsay will inquire of the parties maintaining the New York Subway, he will find that linseed oil paints have absolutely failed under moisture conditions, whereas the asphaltum compounds, of which there are several on the market, are the only ones that have stood the punishment. Confirmation of those facts can be obtained from the Interborough Company of New York.

The President:—Any further discussion? If not, the clause as amended by the insertion of the words, "or such other coating as the engineer shall approve," will be accepted.

Mr. Loweth:—There are two requirements in the specifications: One that the coating shall be of asphalt, and the other that it shall be applied by dipping the rod into a hot mixture. The specifications should be so modified as not to require the rods to be dipped in paint, but permit of its being applied with a brush, as is customary.

The President:—The Committee will accept that suggestion, and insert the words, "the application of such other coating."

Mr. Steffens:—Please state how that will read now.

The President:—"Each hoop shall be cleaned, preferably at the factory, of dirt, rust and scale, and in that condition shall be heated to 300 degrees Fahrenheit, and dipped in pure asphalt, or the application of such other coating as the engineer shall approve."

Mr. Steffens:—To have the coating applied hot or to hot metal?

The President:—By adding the words, "or the application of such other coating as the engineer shall approve," to the end of the clause, will make it read right. The clause will be amended in that form.

The Secretary:—"15. Hoop joints. Hoops shall have round threaded ends passing through lugs. The joint used shall be as designed or selected by the engineer. It shall be as strong as the hoop."

Mr. C. E. Smith:—In clause 13 we say, "may be made of steel." We also say, "the tub hoops shall be half-oval, or half-round," and in clause 15 we say, "they shall have round threaded ends." How does the Committee propose to make the transition from the half-oval or half-round to round ends? If by welding, and the hoop is of steel, I think it will conflict with our steel bridge specifications, which say steel welding will not be permitted.

Mr. Ransom:—It seems that clause 15 should be changed to read, "round hoops shall have round threaded ends, passing through lugs. The joints used for round hoops and all others shall be as designed or selected by the engineer."

The President:—If there is no further discussion, we will proceed.

The Secretary:—"16. Hoop spacing. Hoops shall be of one size, with the spacing varied, limiting the maximum space to 24 in. c. to c. of hoops."

The President:—If there is no objection to that clause, we will proceed.

The Secretary:—"17. Hoop stresses. Hoops shall be so spaced that, for wrought-iron, the stress per sq. in. on net section shall not exceed 10,000 lbs., and for steel 12,000 lbs. Threaded hoops shall preferably have upset ends, but a larger hoop giving the required area under thread without upsetting may be used."

Mr. Loweth: Why is it preferable to require upset ends in clause 17?

Mr. J. L. Campbell:—It appeared to the Committee that an unnecessary amount of metal would be used if the rods were not upset. The strength of the rod would be limited to the strength of the metal under the thread, and these hoops are quite long. It makes a very material difference in the weight of the metal you put on, without securing any advantage, as the Committee sees it.

Mr. Loweth:—That is quite true, but the upsetting for these small rods would cost more than the extra metal, all things considered. Inasmuch as it is a matter of cost which each man can suit himself in regard to, I move that we omit the last two lines of clause 17.

Mr. J. L. Campbell:—The specifications say the rods should be preferably upset, but it was left to the individuals of the Association to use either one.

Mr. Kittredge:—I would say a word in favor of Mr. Loweth's motion—we avoid an inconsistency by omitting these lines. In clause 15 it says, in regard to the joints, that they shall be as strong as the hoops. By omitting the last two lines of this paragraph, we avoid the inconsistency of making a smaller joint than the hoop.

The President:—The last two lines will be omitted.

The Secretary:—"18. Roof. The roof shall preferably be built in the form of a flat dome, as shown, but other forms may be used."

Mr. Lindsay:—This specification, reading as it does, is imperative, and I would like to know what particular virtue the dome roof has. It does not appeal to me from an esthetic standpoint, and I cannot see any economy in it. It will be difficult to make, and difficult to maintain.

Mr. J. L. Campbell:—The Committee believes that the form of roof shown is simple and economical, as much so as any other form of roof, and probably more easily constructed than the more ordinary forms of roofs. The specifications leave the selection of the form of roof optional.

Mr. Lindsay:—Will the Committee substitute the word "will" for "shall" in the first line?

The President:—That is acceptable to the Committee.

Mr. Loweth:—I agree that the form of roof specified would be satisfactory, in that it would present a good appearance, and cost but a trifle more than the ordinary cone roof; but even so, why should the Association adopt the dome roof in preference to anything else, especially in view of the prevalence of other forms than that recommended? I see no occasion for such action, and move that the word "preferably" be stricken out.

The President:—The Committee accepts Mr. Lindsay's suggestion.

Mr. McDonald:—That will not remove Mr. Loweth's objection. If you strike out the word "preferably," that makes it imperative that it shall be built with a dome.

The President:—The Committee suggests the use of the word "may" instead of "shall."

Mr. Shurtleff:—It seems to me that, instead of going into specifications, our specifications are going into designs which will be covered by plans. I suggest that the paragraph be stricken out entirely and that a new paragraph be provided specifying that the roof shall be according to standard plans, which will cover the details, but details of plans should not be specifically mentioned in the specifications.

Mr. Lindsay:—The standard plan becomes a part of the specification—the standard plan shows a dome roof, and if we omit the specification, we would be really worse off than we are now.

Mr. Loweth:—I second Mr. Shurtleff's motion.

Mr. J. L. Campbell:—It seems to me on that basis we could make our specifications very short. We could simply say, "the tanks should be built according to the plans." It seems to me that would be all that is necessary in these specifications, on that basis.

Mr. Loweth:—Has the Committee any information as to the number of railways that have built tanks with roofs of this design? The Committee is asking the Association to adopt specifications in which it is stated that this type of roof is preferable, but gives no reason therefor. I do not know of any roads which have been using this type of roof.

Mr. Ransom:—I would say that two years ago we attempted to get standard plans of tanks from the railroads of the country. We received many answers to our inquiry, which indicated that the question of water tanks had not received much consideration for thirty years. On most of the railroads, the Committee was unable to definitely determine what the best practice on railroads was in regard to tank design, and it has been up against that situation ever since the question of tank design was brought up. The bulk of the railroads apparently have considered the question of tank design a secondary matter, and paid very little attention to it, although some roads have considered it very carefully.

Mr. Ferriday:—I will say in connection with the roof design, that you might specify a certain type of roof this year and show plans calling for a pyramidal roof, or conical roof, have that referred back to the Committee, and then show some other type next year, and another type the year after, and the only way we can get together is by a compromise. It is not claimed that this is the cheapest or best type of roof, or perhaps the most artistic, but we have to show some sort of roof.

If the consensus of the Association is that this form is not desirable, we would like some pretty full discussion, so that some form may be decided on in the convention here, and that could be shown in our plans and in our specifications.

Mr. Shurtleff:—With reference to Mr. Campbell's statement, I believe that a specification should specify materials used and workmanship, but later on, if they are going to call on this Association to adopt this plan, which is submitted with this specification and details, I doubt if they will secure the adoption of the specifications by the Association. Of course, that remains to be seen. I am making my motion with the idea that the wishes of the Committee that are acceptable will be adopted, but hardly feel that the Association will adopt the plans as submitted, to go into the Manual.

Mr. J. M. Meade (Santa Fe):—I will state, for the benefit of the Association, that the Santa Fe is building its standard steel tanks without any roof, from Illinois to the Pacific coast.

The President:—You are not in a country where the temperature gets to 20 degrees below zero?

Mr. Meade:—It gets pretty near to that.

Mr. McDonald:—I believe we have reached a point in the conduct of the affairs of this Association when we should lay down the principle on which our work should be prepared in the future. Every time plans are presented there is continual objection, and we have never succeeded in introducing a set of plans into our Manual. If we are making a mistake in instructing our committees to bring in definite specifications and recommendations, then the Association should so express itself.

Last year, when this report came up, the Committee presented detailed specifications, and the criticism was that they were not in sufficient detail, and it was instructed to again take up the subject and bring in specific recommendations. The Committee has followed the instructions in the report it has presented at this convention. If this is wrong practice, our committees in the future, it seems to me, should be instructed to bring in only recommendations as to the underlying principles, and leave plans out. I believe our convention should express itself on that theory, so that our work may be properly arranged for the future, and we may not be called upon to consume the time of the convention in discussing questions of design, which are constantly meeting with opposition on account of varying standards on the different roads.

Mr. J. L. Campbell:—I believe I voice the sentiments of this particular Committee when I say "amen" to those remarks.

The President:—Mr. McDonald's remarks are very opportune. I believe it is the province of the Board of Direction to lay down in its instructions to the committees some specific rules of procedure.

Mr. J. B. Jenkins (Baltimore & Ohio):—In the matter of committee reports, the convention has usually objected to specifications and plans, on the one hand, as not being sufficiently complete, and, on the other hand, as being too complete and specific, and that public service commissions might object to other and equally correct standards of practice on account of not conforming strictly to those recommended by this Association. Thus every committee has been between two fires. It seems to me it might be well for this convention to request the Board of Direction to draw up a preface to our Manual, which would state, in effect, that while the practice recommended in the Manual is considered good practice, it is not necessarily the only good practice and that it is not intended to exclude any other methods, plans or specifications which may arrive at the desired result.

The President:—For the information of the Association, I will state that the Board has practically agreed on such a rule, which will appear in the new Manual. Is there any further discussion on the question?

(Mr. Shurtleff's motion was lost.)

The President:—It will be necessary, on account of the amendment of clause 18, to amend 19, 20, 21, 22 and 23, and if the convention will accept it, the Committee will amend these sections to conform to clause 18. The changes will be made to harmonize with the statement, "the roof may be built," etc. If there is no objection, these paragraphs will be referred to the Committee to be amended in conformity with clause 18, as amended.

We will now proceed to clause 24.

The Secretary:—"24. Frostproof floor. When required for frostproofing, the roof shall be oiled, as shown. Where ice will not form to an injurious or troublesome degree and sunlight will not cause vegetable growth in the water, the entire roof and ceiling may be omitted.

"25. Frost shaft. The frost shaft, extending from the frost pit to the bottom of the tub, shall be constructed, as shown, enclosing it by multiple walls of 1-in. by 6-in. lumber, S 1 S and 2 E, separated by 2-in. by 4-in. studding on edge or side. Each wall shall have two courses of lumber separated by a layer of heavy tar felt. The outside course shall be tongued and grooved. The number of walls shall be sufficient to prevent water in the enclosed pipe from freezing. A frostproof door in one side of the shaft shall be constructed as designed by the engineer.

"Where ice will not form, the entire frostproofing, including pit, may be omitted."

Mr. Lindsay:—Does paragraph 25 confine us to the particular type of frostproofing described? There are other forms as economical in material and as satisfactory. I refer to the use of dead air spaces around each pipe.

Mr. Ransom:—That is what this covers.

Mr. Lindsay:—I mean dead air spaces around each individual pipe, or around two or three pipes, with different designs of tank. We ought to be liberal enough to admit that form, I think.

Mr. Ransom:—This specification is simply for a wooden tank and the design you speak of would not be very often used in a wooden tank.

Mr. P. C. Newbegin (Bangor & Aroostook):—I do not think this frostproofing as shown would answer for a very cold climate. Up in Northeastern Maine we have temperatures down to 40 degrees below zero, and the only way we can keep our tanks free from ice is to enclose the entire bottom of the tank and put in a stove, and run a pipe from the stove through the water in the tank and keep a fire continually in the stove.

Mr. Lloyd:—I was brought up in the Northwest, where they have as cold weather as in Maine, and we arranged our frostproofing in the same way as that outlined in the report. We did not find it necessary to use a stove.

The Secretary:—"26. Lumber. All lumber in the roof and frost-proofing shall be No. 1 common, as rated by the Lumbermen's Association for the district supplying the material.

"27. Piping. The tank shall be equipped with a tank supply pipe, a water-column supply pipe and an overflow pipe, as shown. The first two shall be provided with gate valves. For a gravity supply the tank supply pipe shall be carried to the top of the tank and capped by a float valve. The sizes of the pipe shall be determined by the engineer. No pipes shall have an inside diameter less than 4 in. All pipes shall pass through the bottom of the tank by two standard flanges full bolted with gaskets. For a pressure gravity supply, a stuffing box in lieu of flanges for the tank supply pipe may be used if necessary to prevent leakage. All pipes shall be enclosed in the frost shaft and pit and leave the latter below the frost line."

Mr. Loweth:—I ask the Committee if it is always necessary to have the water supply pipes and the discharge pipes separate? There are many cases where the two can be combined in one. This design is prefaced with the statement that the tank is designed to deliver water to locomotive through water columns. I think the practice is to separate the two pipes.

Mr. Lindsay:—Our experience recently has been that the float valve can be very much improved upon by the use of an automatic valve in the frost pit. The float valve, in places where you are troubled with considerable ice, is very often frozen up, and does not regulate the supply. While I judge the specification does not prohibit the use of such a device, I call it to the attention of the Association. There is also an improvement that can be made in the elbow in the frost pit, at the base of the supply pipe, where the supply pipe rises to supply the tank. If this is made a tee instead of an elbow and provided with a plug, the sediment, which gathers at the foot of the supply pipe and interferes with the supply, can be blown out.

Mr. Loweth:—I wish to take exception to the Chairman's statement that the best practice requires the use of separate inlet and outlet pipes. That is frequently not the case. Many times money is saved by making one pipe serve both purposes.

Mr. A. W. Johnston (New York, Chicago & St. Louis):—I do not wish to appear hypercritical in reading the specifications, but in one part of clause 27 it says, "the size of the pipe shall be determined by the engineer." It also says, "no pipe shall have an inside diameter less than 4 in." Why specify the limiting size?

The President:—That is in order to check the judgment of the engineer.

Mr. Lloyd:—Gravity lines are supposed to carry the water up into the tank. We have places where we use only 3-in. pipe—the head is only 2 or 3 ft. above the top of the tank. If we carry the gravity pipe to the top of tank, we reduce the supply of water by reducing the head; whereas, if the pipe line is cut off just above the bottom of the tub, we get additional head and consequently an increased supply, varying with the height of water in tank.

Mr. J. L. Campbell:—In this tank, used in connection with a water column, that has no connection with the delivery to the water column. The water is drawn from the bottom of the tank, as the plan shows, through the 12-in. pipe.

Mr. Lloyd:—The gravity lines mentioned have reference to the supply to the tank, not to draw off from the tank.

The Secretary:—"28. Sludge hole. In the bottom of the tank outside of the frost shaft a sludge hole with plug shall be constructed as designed or selected by the engineer."

Mr. Lindsay:—A sludge hole in the bottom of the tank is a very dirty and uneconomical arrangement. When you open the hole and let the sludge out, it goes all over the substructure, and smears it, and you must wash it off, or repaint it. There should be a pipe from the sludge hole to a suitable point on the ground. I think the sludge hole should be equipped with a better device than a plug of wood. There should be a recessed cast-iron cap that could be put on the hole and tightened down so as to prevent leakage.

Mr. Ransom:—That is a question of detail in the design which the Committee did not consider.

The Secretary:—"29. Water tightness. When the tank is finished, the hoops properly tightened and the wood saturated, the tub shall be water tight. No foreign material shall be used in making the joints in the tub.

"30. Gage. The tank shall be equipped with a gage, indicator and float as designed or selected by the engineer. The clearance between the gage board and the tub shall not be less than 1 in.

"31. Ladders. The ladders shall be constructed, as shown, and as designed or selected by the engineer.

"32. Painting. All exposed woodwork shall be painted with one priming and two finishing coats, using the company's standard paint and colors for such work. All wood to be painted shall be dressed.

"33. Definitions. The words 'company,' 'engineer,' 'as shown,' 'drawings' and 'this Association' appearing in these specifications are defined as follows:

" 'Company' means the railway company building a tank under these specifications.

" 'Engineer' means the engineer of the company.

" 'Drawings' means the drawings of the tank herein specified and forming a part of these specifications, including such working drawings as the engineer shall prepare or approve.

"'As shown' means as shown on the drawings.

"'This Association' means the American Railway Engineering and Maintenance of Way Association."

Mr. Lindsay:—I submit that the definitions in paragraph 33 should occur as paragraph 1.

The President:—The Committee accepts the suggestion.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I desire to introduce a motion. We are now twelve years old as an Association, and there is a very sharp difference of view as to whether a Manual should be published or not. There is also a very decided difference of view as to what should enter into the Manual. I believe we have reached a point where the Manual should contain less subject-matter. The original purpose in publishing a Manual probably has never been stated. I do not know what that original purpose was, except as we find on the index page of the Manual, but it is my personal opinion that the greatest value of the Manual lies in the fact that it should contain general specifications, which will enable railroads to obtain competition in the purchase of materials. As a primary object, that would justify its existence. My thought is, that it should contain well-defined principles which could be followed by engineers generally.

Again, to introduce standard plans into the Manual may or may not be desirable, but I think it is out of the question to introduce into the Manual standard designs of structures. We might follow this question by discussion for a long time, but I submit that we have reached the point where it would be fair to lay down the general principle that committees may prepare standard plans, not with reference to having them adopted as parts of the Manual, but for the purpose of having them approved as information, as to best designs suitable to definitely prescribed conditions.

I therefore move that the specifications as heretofore considered under the head of this Committee, and also those under the heading of "Iron and Steel Tanks," be passed, with the understanding that standard designs as to the structures themselves shall not be included in the Manual, and that this be approved as a general practice to be followed in the future by the Association.

The President:—The Committee states that they are perfectly willing that these specifications and plans shall be accepted as information, but they are not willing to have the matter referred back to them. They claim they have performed good service, given intelligent thought and attention to this subject, and that the Association should recognize it, but that to refer it back to the Committee to prepare a report next year, to meet with the same objections as this year, would mean an endless-chain arrangement.

Mr. W. C. Cushing (Pennsylvania Lines):—I second Mr. Wendt's motion.

Mr. Loweth:—I doubt if I understand just what is included in Mr. Wendt's motion; it seems to include not only the disposition of this report, but also a question of future policy. I would like to have the motion put in writing before we act on it, so that we may vote on it understandingly.

The President:—The Chair thinks this is a matter which should come under the heading of "New Business," and is not in order at this time. It is important, and should not be overlooked.

Mr. Wendt:—I will make my motion to read that the report of this Committee be received as information in accordance with General Rule No. I.

The President:—Under that motion, it will not be necessary, unless the convention so desires, to take up the plans for the iron or steel water and oil tanks, which follow in the remaining conclusions of the Committee.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—I think this is a question we should have some consideration on. What standing has this report if the convention passes a rule that it is received as information?

The President:—It will then be published in the Proceedings and be a matter of reference for the members of the Association.

Mr. Rose:—It would be published in the Proceedings, if the convention had returned it to the Committee?

The President:—It would.

Mr. Rose:—The great objection I see to the adoption of this rule is that these reports are very often disconnected.

The President:—This question will come up under "New Business." Are your ideas in reference particularly to the report under consideration, or are they of a general nature?

Mr. Rose:—I think my ideas are general, and I will sit down.

The President:—The Chair understands that Mr. Wendt's motion applies to the conclusions of the Committee as they appear on page 92.

Mr. Wendt—My motion was intended to include the entire report of this Committee, and my action, as I understand it, is in accordance with the wishes of the Committee that it be received as information and not referred back.

The President:—It applies to this particular specification only, the one we have just been discussing. The Committee points out that the general specifications for ordinary iron or steel water and oil tanks is an important matter, and the Chair would like the Association to decide whether it shall be discussed or not.

Mr. Wendt:—I will limit my motion to what has been considered at the present time.

The President:—The motion is that the specifications for wooden water tanks be received as information.

(The motion was carried.)

The President:—We will now proceed to the general specifications for ordinary iron or steel water and oil tanks. The Chair will entertain a motion whether or not these specifications shall be discussed in detail.

Mr. Lindsay:—The hour is growing late, and there are other committees with reports, which we would like to have action on, and inasmuch as the specification for the wooden tank has been disposed of as it has (I believe the Committee will accept it), I move that the specifications for the steel tanks be accepted as information, and written discussion invited.

Mr. J. L. Campbell:—The Committee has no desire to take up the time of this Association, but I desire simply to say that these general specifications for ordinary iron or steel water and oil tanks do not carry with them any plans.

Mr. Ferriday:—These are the specifications we were instructed last year to bring in in greater detail. It is unfortunate the time is going by, but I do not think we should dispose of the entire work of the Committee by accepting it as information. We want the wooden tank accepted as information, if it cannot be adopted and put in the Manual. We would like to have that done with the iron and steel tanks, so that we can get done with this subject and pass on to something else. I think that the iron or steel water and oil tanks should be discussed in detail.

Mr. William McNab (Grand Trunk):—Does Mr. Lindsay anticipate that the members of this Association will turn in any discussion in writing? We have had experience in regard to that in the past, and I do not think the written discussion which we would receive from the members on this report would, in quantity, materially add to the volume of our Proceedings.

The President:—The Chair would say, if there is no objection, that we can read the headings of the paragraphs, give the members time to read the matter, and if there is no discussion or objection, to proceed to the following paragraphs. Mr. Lindsay's motion does not necessarily restrict the discussion.

Mr. McNab:—It was made for that purpose.

(Mr. Lindsay's motion was lost.)

Mr. Kittredge:—I move that at 1 o'clock the discussion of all Committee reports shall cease. The time is growing short. There is other business for this Association to do, and it seems that only by some such action as that we will be in any condition to finish up work which it is absolutely necessary should be done. With that information before us, it may enable us to decide quickly what action to take in regard to any special committee. I suggest that the remaining time at our disposal between now and 1 o'clock be divided among the different Committees which have yet to report on some basis to be determined by the Chair.

The President:—It is moved and seconded that at 1 o'clock this convention cease the discussion of Committee reports and proceed to the remaining business.

(The motion carried.)

Mr. Rose:—I move that the balance of the time be given to the Water Service Committee, for they need it.

Mr. Shurtleff:—I move that the specifications for iron and steel tanks be submitted to the Association for letter-ballot for adoption in the Manual.

Mr. McDonald:—I ask what the status of the report would be if it is adopted by letter-ballot? I do not know of any provision in our rules covering voting by letter-ballot.

Mr. McNab:—Does it mean simply, answer "Yes," or "No," accept them in whole or discard them?

The President:—You might just as well, in the opinion of the Chair, disapprove the report of the Committee as to submit it to letter-ballot under our usual form of procedure.

Mr. Shurtleff:—I withdraw the motion.

Mr. McDonald:—I move that this report be received as information under Rule 16-a. That will put it in the position that if the Board of Direction see fit to refer this matter again to that Committee, for a further report next year, they may do so, and if they do not see fit to do so, that it remains published in the Proceedings as presented, without further discussion.

The President:—You mean it shall be accepted as information without discussion now?

Mr. McDonald:—Yes.

Mr. McNab:—Is this the main idea of Mr. McDonald's motion, that the time is too limited to discuss the report?

Mr. McDonald—I confess that is the main idea. I know there are other important matters to be discussed—other reports—and I do not believe we are going to have the time to give them the consideration they should have, and I think we all realize the mistake our committees are making—or rather the instructions to the committees, and the committees themselves are both at fault—in undertaking to give this convention more food that it can digest in the time at its disposal. It should be left discretionary with the Committee to bring in such information as they feel can be reasonably disposed of in a reasonable time. To give this report proper discussion would consume 48 hours. I believe that we can dispose of the reports of a number of these other committees in a shorter time, and this Committee has certainly had its innings on one subject, anyhow.

Mr. Rose:—I think we had better carry the Water Service Committee to the end of the time available, and settle it, rather than to turn this Committee loose, and then run two or three other committees over the rack.

(Mr. McDonald's motion carried.)

The President:—The Committee is relieved with the thanks of the Association for the excellent work it has done.

REPORT OF COMMITTEE XI.—ON RECORDS AND ACCOUNTS.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

(I) OUTLINE OF WORK.

The Board of Direction assigned the following work to your Committee for the current year:

(1) Recommend a form and system for keeping sidetrack records.

(2) Continue the study of estimate forms for construction and maintenance work.

(3) Consider revision of the Manual; if no changes are recommended, make statement accordingly.

(4) Make concise recommendations for next year's work.

(II) ORGANIZATION FOR SUB-COMMITTEE WORK.

Sub-Committee A—Sidetrack Records:
M. C. Byers, Chairman.
C. W. Pifer.
Thomas Maney.

Sub-Committee B—Bridge Estimate Forms:
Edward Gray, Chairman.
R. W. Willis.
E. E. Hanna.

Sub-Committee C—Building Estimate Forms:
W. H. Sellew, Chairman.
J. H. Milburn.

Sub-Committee D—Water Service Estimate Forms:
C. H. Gerber, Chairman.
J. M. Brown.

Sub-Committee E—Section Foreman's Material Report:
Henry Lehn, Chairman.
J. E. Turk.
T. H. Gatlin.

The general plan of conducting the work was the same as heretofore, of dividing the Committee membership into sub-committees to handle the individual subjects; the sub-committees reported their results and made recommendations to the General Committee at meetings held in Chicago, September 12, 1910, and January 7, 1911.

(III) SUB-COMMITTEE REPORTS.

Sub-Committee A—Sidetrack Records.

(a) Instructions.

The work outlined for this Sub-Committee was as follows:

(1) To collect data in the nature of forms and methods used by railroads for keeping sidetrack records.

(2) To formulate a definite recommendation for a method of preparing and keeping such records, with particular attention to the following features:

- (1) Reporting completion of sidetracks.
- (2) Keeping permanent record of same.
- (3) Periodically checking location and length to ensure the record always being correct.

The information considered desirable for such a record generally consists of the following:

- (1) Location of sidetrack by mile post and station.
- (2) Length.
- (3) Alinement.
- (4) Gradient.
- (5) Actual cost and by whom assumed.
- (6) Character, age and weight of rail.
- (7) Character and size of ties.
- (8) Description of bridges and culverts.
- (9) Date of construction.
- (10) Memorandum of agreement, if any, covering construction and maintenance.
- (11) Title to property occupied.

A general request was made for sample forms, which forms guided the Sub-Committee in the investigation of the subject.

(b) Discussion.

The investigation developed that the railroad companies have not as a general thing devised very complete systems for keeping sidetrack records, although the necessity for such is generally admitted but not fully appreciated. There would seem to be no reason why the same care should not be given to maintaining careful records of sidetracks as is given to keeping records of main tracks and other physical assets of a railroad company.

In the analysis of the subject the Sub-Committee came to the conclusion that a sidetrack record should be used for the following reasons:

- (1) To provide data for compiling reports to State Railroad Commissions and the Interstate Commerce Commission.

(2) To provide data for annual reports.

(3) Keep a record of ownership of sidetracks.

(4) Keep records for taxation purposes.

(5) Provide a convenient method by which the officers of a railroad in direct charge of maintenance or changing of sidetracks may become familiar with the conditions under which the tracks are constructed and maintained. This is especially valuable in connection with sidetracks which are owned wholly or in part by private parties or corporations, the maintenance of which is performed by the railroad company and the cost charged against the owner.

Failure to keep accurate sidetrack records has resulted in much controversy between interested parties and oftentimes endless search through correspondence files in order to develop the information which ought to be readily found and for which there is constant call. In a large percentage of industrial tracks there are other than railroad interests. The title to the track and property and maintenance of same makes it just as important to keep a complete and accurate record, which should supplement the written contracts, as to keep records of titled property. In addition, there is necessity for keeping better records on account of constantly increasing demands of local and national authorities for data in connection with physical condition of property, for which reliable records must be within easy reach. It is felt that the importance of this feature of railroad records cannot be too greatly emphasized and that it has not heretofore been given the prominence it deserves.

The Committee presents to the Association for adoption the form proposed for sidetrack records, identified as Exhibit A. This form, while possibly giving the impression that it may be elaborate, will, upon examination, be found to contain only such information as is of value, and the labor and time involved in keeping such a record would not amount to much after it has once been prepared.

The general scheme of the form is to have a permanent record, which will be corrected annually and which will, as far as possible, show accurately the track situation at all times, and it is so planned as to permit additions or reductions in length to be indicated immediately upon completion of the work without causing the form to be rewritten.

The form needs very little explanation, as the headings of the columns show exactly what information is to be recorded. In presenting this form the Committee has in mind the necessity for a form that will fit all conditions, and this accounts for four or five columns which show in different methods the location of track, as the same method for indicating the location could not be used under all conditions.

It is proposed that this form be printed on tracing paper, so that as many copies as are desired can be taken from it by blueprinting, the original to be retained in the local office. At the end of the year or other prescribed period the local officers should correct the report and send new prints to the office of the Chief Engineer or whatever general officers may require such information.

In detailed explanation of the use of the columns the following instructions are proposed to accompany this form:

Column No. 1.

Show location of sidetracks referred to mile posts, which method would be used for tracks which are not a part of yards or within station limits. In such cases the mile post location will be the mile and plus of the switch nearest the mile post measured in the direction in which the mileage is carried.

Column No. 2.

Give reference indicating that the sidetrack is on the right or left side of the main track.

Column No. 3.

Give name of station at which track is located.

Column No. 4.

Give name of county and state.

Column No. 5.

Give name or number of township or school district.

Column No. 6.

Give name or number of track, as it may be designated.

Column No. 7.

Indicate whether the track is a spur or connected at both ends.

Column No. 8.

Show construction authority number.

Column No. 9.

Give number of contract, if any exists, covering constrution, operation or maintenance.

Column No. 10.

Show date sidetrack was completed.

Column No. 11.

Give character, age and weight of rail.

Columns Nos. 12, 13, 14 and 15.

Show actual length of track at the end of prescribed record year, dividing the ownership between the railroad and outside interests.

Columns Nos. 16, 17, 18 and 19.

Show changes which may be made to track during the record period. In these columns the plus sign should be used to indicate track length which is added, and the minus sign should be used for track length which is taken up.

Column No. 20.

Show any miscellaneous information that has a bearing upon the track and which is not provided for by separate column.

A space should be provided between the various stations to permit of additional sidetracks being recorded without making a new sheet.

All totals and all figures indicating changes during the year should be shown on the tracing paper in pencil, also the last two figures of the year in which the report is made, but all other figures should be made with India ink. The local officers preparing the sidetrack record should retain the original form and at the end of the period for which the report is to be made, should, after correcting their previous reports to date, send the necessary sets of blue prints to the office of the Chief Engineer, one for use until a new report is made, and the others to be filed as a permanent record. The tracing paper form should not be used for reference but be filed in a dustproof box until it is necessary to correct it or make necessary blue print copies.

All tracks should be reported on the sidetrack record in linear feet of track.

In reporting weight of rail with which the original track was constructed, this should be reported as linear feet of track.

The Committee recommends to the Association for adoption in the Manual of Recommended Practice the proposed form for sidetrack record shown as Exhibit A.

SUB-COMMITTEE B—BRIDGE ESTIMATE FORMS.

(a) Instructions.

This Sub-Committee was instructed to continue the study of this subject, which was begun but not completed in the 1909 report, following the general idea of having a form which would provide a uniform method for making such estimates and furnishing a guide to the estimator to avoid errors of omission.

(b) Discussion.

The Sub-Committee very soon determined that it would not be practicable to attempt to follow in the preparation of this form the scheme of printing the various items that enter into general bridge work. The character of construction varies too much to make such a plan feasible, and it was therefore concluded by the Sub-Committee, which conclusion was indorsed by the General Committee, that in the design of such a form the front page should be left blank as far as the list of items is concerned, but that on the reverse side of the sheet should appear a list of the principal items which enter into various kinds of bridge construction and which would be a guide to the estimator, and insure uniform arrangement of items in the estimates and prevent omission of important features.

In the preparation of this list of items it was found quite easy to include too much detail and the Committee has therefore not attempted to go beyond the principal items. The situation in regard to an estimate for bridge work which would fit all classes of structures is somewhat different from the preparation of a similar form for track estimates, but in the design of the face of this form an attempt has been made to make it consistent in arrangement with the form recommended and adopted for track estimates, with the exception of printing the details.

Exhibit B shows the proposed form for the face of this sheet, and it will be observed in this connection that the Committee has adopted a common form for bridge, building and water service estimates.

Exhibit C shows the information which should appear on the reverse side of the estimate for bridge forms and is self-explanatory.

SUB-COMMITTEE C—BUILDING ESTIMATE FORMS.

Instructions to this Sub-Committee were of the same character as those given to Sub-Committee B, and the same general principles apply in designing a form for these estimates. The General Committee indorsed a list of items submitted by the Sub-Committee for use in building estimates, which list is identified as Exhibit D, and to appear on the reverse side of the estimate form.

SUB-COMMITTEE D—WATER SERVICE ESTIMATE FORMS.

The same conditions apply in the preparation of this form as applied to bridge and building work, and the Sub-Committee recommended and secured the approval of the General Committee of the list of items indicated as Exhibit E, to be printed in the reverse side of the estimate form.

In conclusion of the matter of estimate forms the Committee recommends the adoption for the Manual of Recommended Practice of forms designated as Exhibits B. C. D and E.

SUB-COMMITTEE E—SECTION FOREMAN'S MATERIAL REPORT AND REVISION OF THE MANUAL.

The Committee does not offer any suggestion or changes with reference to the general subject of revision of the Manual. The Committee has been unable to do much more than complete the work on estimate forms and preparing sidetrack record, and while some attempt was made to study several of the forms, particularly those applying to section foreman's material reports, adopted by the Association, nothing conclusive was determined in this direction.

Respectfully submitted,

H. R. SAFFORD, Vice-President, Edgar Allen American Manganese Steel Company, Chicago, Ill., *Chairman.*

H. J. PFEIFER, Engineer Maintenance of Way, Terminal Railroad Association, St. Louis, Mo., *Vice-Chairman.*

J. M. BROWN, District Engineer, Chicago, Rock Island & Pacific Railway, Davenport, Ia.

M. C. BYERS, Chief Engineer, St. Louis & San Francisco Railroad, St. Louis, Mo.

T. H. GATLIN, Engineer Maintenance of Way, Southern Railway, Knoxville, Tenn.

C. H. GERBER, Consulting Engineer, Omaha, Neb.

EXHIBIT "A."

Side Track Record.

A. B. & C. R. R. Co.—Side Track Record

Side Tracks on ______________ Division ______________ Sub-Division ______________

EDWARD GRAY, Engineer Maintenance of Way, Southern Railway, St. Louis, Mo.

E. E. HANNA, Division Engineer, Missouri Pacific Railway, Aurora, Mo.

HENRY LEHN, Maintenance of Way Accountant, New York Central & Hudson River Railroad, New York, N. Y.

THOS. MANEY, General Roadmaster, Louisville & Nashville Railroad, Louisville, Ky.

J. H. MILBURN, Chief Draftsman, Baltimore & Ohio Railroad, Baltimore, Md.

C. W. PIFER, Roadmaster, Illinois Central Railroad, Clinton, Ill.

W. H. SELLEW, Principal Assistant Engineer, Michigan Central Railroad, Detroit, Mich.

J. E. TURK, Superintendent, Philadelphia & Reading Railway, Tamaqua, Pa.

R. W. WILLIS, Engineer, Missouri District, Chicago, Burlington & Quincy Railroad, St. Louis, Mo.

Committee.

Size, 8½x13½ inches (Approximately).

Exhibit "B"

A. B. & C. R. R. CO.

Proposed Form for Estimates for { **Building** / **Bridge** / **Water Service** } **Construction**
(Face of Form)

Plan No.____________

Authority No.____________ Estimate No.____________

____________ Division

Estimate of Cost of ________________________

Prepared __________ Date __________ By __________ Name __________

Estimate must be itemized under the various headings shown on back of sheet.

Items	Labor		Material						Total	
			Quantity		Unit Cost		Total			
Total										

Cost of Reproducing Abandoned Facilities ____________________

Distribution of Cost:

To Maintenance or Operation.____________________

To Betterment.____________________

To Outside Companies or Individuals.____________________

Exhibit "C"

Reverse Side of Form Proposed for Estimate for Building Construction.

BUILDING ESTIMATE

Items	Details
1. Preparation of Site.	Grading, Removal of Buildings, etc.
2. Foundation.	Excavation and Foundation material in place.
3. Body Brick Steel Concrete Framework	All material in place, comprising the frame work of the building except items listed separately.
4. Platforms and Sidewalks.	All platforms either attached or built in connection with building. Give separate estimates for each type, where more than one is to be used.
5. Driveways.	Give separate estimates for each type where more than one type is used.
6. Flooring.	Cost of materials above joists.
7. Plastering.	Including lathing.
8. Painting and Decorating.	Interior and Exterior painting and glazing.
9. Fire Protection.	
10. Lighting.	
11. Hardware.	
12. Heating.	
13. Water Supply.	All expense of Water Supply outside of building proper.
14. Plumbing.	
15. Sewerage.	All expense of Sewerage outside of building proper.
16. Roofing.	All materials in place above Sheathing.
17. Guttering and Downspouts.	
18. Furniture.	
19. Scales.	
20. Elevators and Conveying Facilities.	
Credits	Covering Salvage and to be itemized as above.

Exhibit "D"

Reverse Side of Proposed Form for Estimates for Bridges.

Items	Details
1. Additional Land.	Real Estate, Easements.
2. Foundation.	Excavation, Altering Existing Structure, Sheet Piling. Coffer Dam, Piling and Grillage, all expense to prepare for Footing.
3. Substructure.	Masonry Footings, Pile Piers, Masonry Piers, Steel Piers.
4. Superstructure.	Steel Erection, Decking, Painting. Masonry Arches, Water Proofing, Reinforcing. Iron, Concrete and other types of Culvert Pipe.
5. Filling and Back Filling and Cleaning.	
6. Train Service.	
7. Miscellaneous.	
8. Engineering and Train Service.	
Credits	

Exhibit "B"

Reverse Side of Proposed Form for Estimate for Water Service Construction.

Items	Details
1. Right-of-Way.	Easement, Water Right.
2. Grading.	Clearing, Excavation Trenching, Back Filling.
3. Fencing.	
4. Telephone.	Line, Instruments.
5. Bridges and Structures.	Dams, Wells, Tanks or Stand Pipes, Water Column. Softeners, Filter. Wind Mill, Track Pan, Power House, Outbuildings, Pumper's Dwelling, Pipe Lines.
6. Machinery.	Boilers, Engines, Motors, Pumps.
7. Transportation.	Men and Materials.
8. Engineering.	
9. General Expense.	
Credits	

DISCUSSION.

(The report of the Committee on Records and Accounts was presented by the Chairman, Mr. H. R. Safford.)

Mr. H. R. Safford:—The work assigned to us this year was: First, the design of form for keeping sidetrack records; second, to continue the study of estimate forms; third, revision of the Manual, and, fourth, recommendations for next year's work. In brief the Committee feels that the most important of these items was the preparation of the form for sidetrack records. The Committee felt that this was a matter which had not been given a great deal of attention by railroads in general, and that fact was confirmed by inquiries which we made, which resulted in practically no responses, indicating that railroads had established no well-defined forms for that purpose. Certainly the matter of keeping careful and completed sidetrack records is just as important as keeping main track records, because it is an asset of the same kind and represents a great deal of value. Opposite page 192 of the Bulletin appears a copy of the form the Committee has prepared after a great deal of discussion, and we feel that it meets all possible conditions. On page 186 appears a brief description of how this record is to be kept and maintained, the idea being to make this on tracing paper, have it corrected annually and kept in the local office, and blueprints taken from time to time as may be desired, to be submitted to the various offices of the system who need such a record. I believe the form is clear in its outline and needs very little explanation, and for the purpose of getting the matter before the Association for action, I move the adoption of the form for sidetrack records as proposed.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I would like to ask the Committee whether they gave consideration to the question of groups, of large yard groups. Is it the intention that each track in a group shall be placed on this blank, or are they to be treated as groups on the blank?

Mr. Safford:—The idea was that a condition of that kind can be listed as a group. We could not individualize with every track in a large yard.

Mr. McDonald:—Is this intended more for industrial tracks?

Mr. Safford:—It is intended to be a record of all sidetracks that may be considered as individual tracks or in an isolated location. It is not intended to cover groups, that is, each separate track should not have a place in the report.

Mr. C. H. Spencer (Washington Terminal Company):—I would like to ask the Committee whether in getting up this record they referred to the sidetrack as defined in the revision of the Manual and adopted by this Association last year as a specific definition of sidetrack?

Mr. Safford:—Yes; that is consistent with that definition.

Mr. G. D. Brooke (Baltimore & Ohio) :—There is one omission that I would like to see taken care of. Nearly all private sidings are covered by agreements, and this would be a convenient place for filing reference to them.

Mr. Safford :—Column 9 covers it. It should be "Contract number" instead of "Construction number."

The President :—That will be corrected.

(The motion carried.)

Mr. Safford :—The next is "Water Service Estimate Forms." The Committee secured the adoption last year of a form for sidetrack estimates and general estimates in connection with track work and pursued this study to the conclusion which is represented by the forms on pages 190, 191, 192 and 193, which cover bridge, building and water service construction. In the design of these forms we could not undertake to provide a printed list of all the items that went into the construction of bridges, buildings and water service. So we felt that we should not go further than to recommend a blank, showing the proper columns for labor and material unit cost, and so forth, proper identification of plan and other features that would appear on such a form, and on the back of that form give a brief outline of the principal items that form that construction, merely as a guide to the person making the estimate. We could think of innumerable sub-headings under each of these subjects, but we felt that that was unnecessary, because construction varies so greatly; so for that reason we feel that we should be somewhat brief and somewhat general as far as that feature is concerned, and these pages will show the extent of our study. For the purpose of getting it before the Association I move the adoption of the forms shown on pages 190 to 193 inclusive. Form 190 is a common form for all three subjects. It was not necessary to duplicate the form for each service. I might add that in the design of the forms, particularly the one on page 190, we have been absolutely consistent with the forms adopted for sidetrack headings.

Mr. George W. Kittredge (New York Central & Hudson River) :—On page 193, the 9th item is "General Expense." I would like to ask for some explanation of that.

Mr. Safford :—That was really intended to mean a general heading for what might follow in the way of miscellaneous items that were not listed. The classification of the things that are ordinarily met in estimates of that kind appear in items 1 to 8. From that point on, it is miscellaneous that we did not feel like listing in detail.

Mr. Kittredge :—I was wondering why it did not appear in the other blanks.

Mr. Safford :—It should have appeared in the others. That was an oversight.

The President :—The Committee will add that to the blanks in which it does not now appear.

Mr. Kittredge :—On page 192, "Engineering" and "Train Service" are grouped together in article 8, while in article 6, the articles "Train Service" is given again. Is there some special kind of engineering and train service covered?

Mr. Safford:—That is another typographical error.

The President:—"And train service" will be omitted.

Mr. Brooke:—I suggest "Miscellaneous Expense" instead of "General Expense" on page 193.

The President:—That is acceptable to the Committee.

(The motion carried.)

Mr. Safford:—That practically covers the work of the Committee on the subject of revision of the Manual. We did not undertake any detailed study. There are one or two features that we considered, but we felt that the subject of the study of the Manual should take the Committee's whole time.

The President:—If there is no further discussion on the report, the Committee will be relieved with the thanks of the Association.

REPORT OF COMMITTEE XVII.—ON WOOD PRESERVATION.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The Board of Direction has assigned the following topics to your Committee:

(1) Consider revision of Manual; if no changes are recommended, make statement accordingly.

(2) Extend specifications for timber treatment to include Rueping, Lowry and other widely used processes.

(3) Continue investigation of proper grouping of different timbers for antiseptic treatment.

(4) Present specifications for timber and piles intended for treatment.

(5) Make concise recommendations for next year's work.

Your Committee held three meetings during the year as follows:

Madison, Wis., Forest Products Laboratory, June 4, 1910. The following were present: W. K. Hatt, Chairman; V. K. Hendricks, G. M. Davidson, W. Buehler, E. H. Bowser, A. L. Kuehn, H. F. Weiss, H. Von Schrenk.

Chicago, Ill., office of Secretary, October 21, 1910. The following were present: W. K. Hatt, Chairman; A. L. Kuehn, E. H. Bowser, G. E. Rex, V. K. Hendricks, H. F. Weiss, W. Buehler, E. A. Sterling, G. M. Davidson, by Mr. Fisher; H. M. Newton, Kettle River Company.

Chicago, Ill., office of Secretary, January 17, 18, 1911. The following were present: W. K. Hatt, Chairman; E. H. Bowser, V. K. Hendricks, E. A. Sterling, Earl Stimson, H. Von Schrenk, G. M. Davidson, by Mr. Fisher; W. Buehler, by H. M. Newton; G. E. Rex, H. F. Weiss, E. Bateman, Forest Products Laboratory.

At the first meeting the following sub-committees were appointed:

Sub-Committee "A"—Revision of Manual:
Octave Chanute, Chairman;
V. K. Hendricks,
G. M. Davidson,
Walter Buehler.

Sub-Committee "B"—on Specifications for New Processes:
V. K. Hendricks, Chairman;
A. L. Kuehn,
E. H. Bowser,
G. E. Rex,
W. Buehler,
E. Stimson,
H. F. Weiss.

Sub-Committee "C"—on Grouping:
H. F. Weiss, Chairman;
Octave Chanute,
E. A. Sterling,
A. L. Kuehn.

Sub-Committee "D"—on Specifications for Timber and Piling:
Hermann Von Schrenk, Chairman;
L. Bush,
W. H. Courtenay,
W. K. Hatt.

Sub-Committee "E"—on Statistics:
Octave Chanute, Chairman;
W. H. Courtenay,
E. A. Sterling.

Sub-Committee "F"—on Track Scales for Weighing Ties:
Hermann Von Schrenk, Chairman;
Earl Stimson.

The Committee has suffered a severe loss in the deaths of Octave Chanute and S. M. Rowe, who have been members of the Committee since its creation by the Board of Direction, and who have, by their active services and wise counsel, added so greatly to the value of the work of the Committee. The Committee at its meeting of January 17 passed a resolution deploring the loss of these fellow-workers, and expressing its appreciation of their contributions to the science and art of wood preservation, and of their high professional spirit in putting their information and judgment at the disposal of the public.

REVIEW OF REPORT OF 1909.

The specifications for treatment of ties were thoroughly revised and prepared for insertion in the Manual.

Seven additions to the recommended practice of the Association were recommended.

In addition to the statistics relating to wood preservation, a report of inspection of the ties laid in the Texas track was presented.

A beginning was made of the work of investigating other preservatives than coal-tar creosote and zinc chloride, and mention was made of certain test tracks of which records are becoming available.

A long report of the strength of creosoted and Burnettized timber recorded the available data and drew conclusions as to its strength.

The fundamental considerations underlying the seasoning and grouping of timber intended for treatment were investigated and records of the dry weight of wood and ties tabulated.

A report presented a classification of the rot-producing fungi, and a description of the rotting pit at Stendal, Germany.

REPORT FOR 1910-1911.

REVISION OF MANUAL.

The report of the Sub-Committee on Revision of Manual is reproduced in Appendix A. Certain changes have been recommended in the specifications for creosote oil, which are summarized as follows:

Paragraph 1. The definition of creosote oil restricts its origin to coal tar, and allows an admixture of refined coal tar to the creosote oil.

Paragraph 2. Fixes the per cent. of insoluble matter at 2 per cent. This is necessary to control the amount of free carbon in the oil when coal tar is added thereto.

Paragraph 3. Places an upper limit of 1.10 on the specific gravity. This limit is placed arbitrarily. Inasmuch as the gravity of oil for paving blocks has been fixed at from 1.10 to 1.15, it would seem that the oil for treatment of ties and timbers should not have any higher gravity than the paving-block oil. As experience develops, it will be possible, later, to intelligently fix a limit of the amount of refined coal tar that may be mixed with creosote oil without affecting the viscosity to an extent that will prejudice the penetration.

After some discussion, the statement of the per cents. of the various fractions was kept at the present standard.

In paragraph 5 it is specified that the fraction between 210 and 255° C. shall deposit naphthalene salts on cooling, and the fraction between 315 and 355° C. shall yield solids on cooling. The demand that the oil shall not show any evidence of decomposition as indicated by the presence of dense white fumes in the condenser is intended to guard against adulteration from water-gas tar.

The Committee recommends an additional paragraph to the recommended practice providing for accurate tests of the life of ties, in an especially selected and carefully inspected test track. While it is thought that the use of the dating nail in each tie is justified by its educative value to trackmen and others, yet the accurate determination of the relative life of ties, and their behavior under service, demands a more careful supervision at the hands of trained assistants than is possible under the present system.

The Sub-Committee for piles and timber to be treated proposes an addition to recommended practice providing for the framing of timbers before treatment.

SPECIFICATIONS FOR NEW PROCESSES.

The Sub-Committee on Specifications for New Processes reports that it is impracticable to write specifications for patented processes. They have, therefore, obtained from the persons in control of such processes an accurate description of the method of conducting them. These have been agreed to by those interested. The Committee recommends that these be printed as information, as found in Appendix B.

GROUPING.

The Sub-Committee on Grouping presents a progress report in Appendix C.

SPECIFICATIONS FOR PILES AND TIMBER TO BE TREATED.

The Sub-Committee presents a draft of such specifications in Appendix D. The present standard specifications of the Association have been followed, as far as possible, except that sap restrictions have been removed. With the endeavor to call the attention of the mill men to the desire of the consumer to obtain material with a large amount of sap, rather than all heart pieces, the statement is made in the specifications that sap wood is to be preferred. The reasonable exception is that this change would operate to reduce the cost of material.

An endeavor has been made to eliminate the coarser varieties of such species as Loblolly Pine by specifying a lower limit of rings per inch. It is realized that this limit will vary with the conditions with reference to the timber supply of railroads in different geographical districts, and also with the policy of the railroad in the use of timber structures under main line traffic.

These specifications are presented for discussion.

STATISTICS.

The statistics with reference to the use of wood are presented in Appendix E.

TRACK SCALES FOR WEIGHING TIES.

The specifications adopted last year for tie treatment provided for the occasional weighing of buggy loads, in and out of the cylinder. The subject of track scales has been investigated by the Sub-Committee, whose report appears in Appendix F. The Sub-Committee finds that track scales for weighing ties are now being used occasionally in treating plants in this country and quite generally in Europe. It recommends that a track scale be installed at every treating plant wherever possible.

STRENGTH OF TIES TREATED WITH CRUDE OIL.

Last year's report on Strength of Treated Timber mentioned certain tests of ties treated with crude oil. Subsequent tests on the same ties are reported in Appendix G, and show that the temporary softening of the surface had disappeared upon exposure, but that the reduction of the spike-holding power in the treated ties still remains.

ELECTRICAL CONDUCTIVITY OF TREATED TIES.

The Committee presents in Appendix H the results of investigation of the passage of electrical current through treated and untreated ties of various species.

CONCLUSIONS.

(1) That the revised specifications for creosote oil be adopted for publication in the Manual.

(2) That the two paragraphs, pp. 60 and 71, recommending the selection of a section of track for testing the life of ties, and recommending the framing of timbers before treatment be added to the recommended practice of the Association.

Respectfully submitted,

W. K. Hatt, Professor of Civil Engineering, Purdue University, Lafayette, Ind., *Chairman.*

W. H. Courtenay, Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky., *Vice-Chairman.*

E. H. Bowser, Chief Timber Inspector, Illinois Central Railroad, Memphis, Tenn.

Walter Buehler, Consulting Engineer, Kettle River Company, St. Louis, Mo.

Lincoln Bush, Consulting Engineer, New York, N. Y.

G. M. Davidson, Chemist, Chicago & Northwestern Railway, Chicago, Ill.

George E. Rex, Manager Treating Plants, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

V. K. Hendricks, Office Engineer, St. Louis & San Francisco Railroad, St. Louis, Mo.

A. L. Kuehn, General Superintendent, American Creosoting Company, Chicago, Ill.

E. A. Sterling, Forester, Pennsylvania Railroad, Philadelphia, Pa.

Earl Stimson, Chief Engineer Maintenance of Way, Baltimore & Ohio Railroad, Baltimore, Md.

Hermann von Schrenk, Supervisor of Timber Preservation, Rock Island, Frisco and Chicago & Eastern Illinois Railways, St. Louis, Mo.

Howard F. Weiss, Forest Service, United States Department of Agriculture, Madison, Wis.

Committee.

Appendix A.

REPORT OF SUB-COMMITTEE ON REVISION OF MANUAL.

AS REVISED.

STANDARD SPECIFICATION FOR CREOSOTE OIL.

1. The creosote oil used shall be defined as a product obtained entirely from coal gas or coke-oven tar, containing no admixture of any tar, oil or residue obtained from petroleum or any other source, except coal gas or coke-oven tar, said creosote oil fully meeting the following requirements:

2. It must be completely liquid at thirty-eight (38) degrees C., and not more than two (2) per cent. of the water-free oil shall be insoluble in chloroform or benzol.

3. The specific gravity of the oil at thirty-eight (38) degrees C. must be at least 1.03, and should not exceed 1.10.

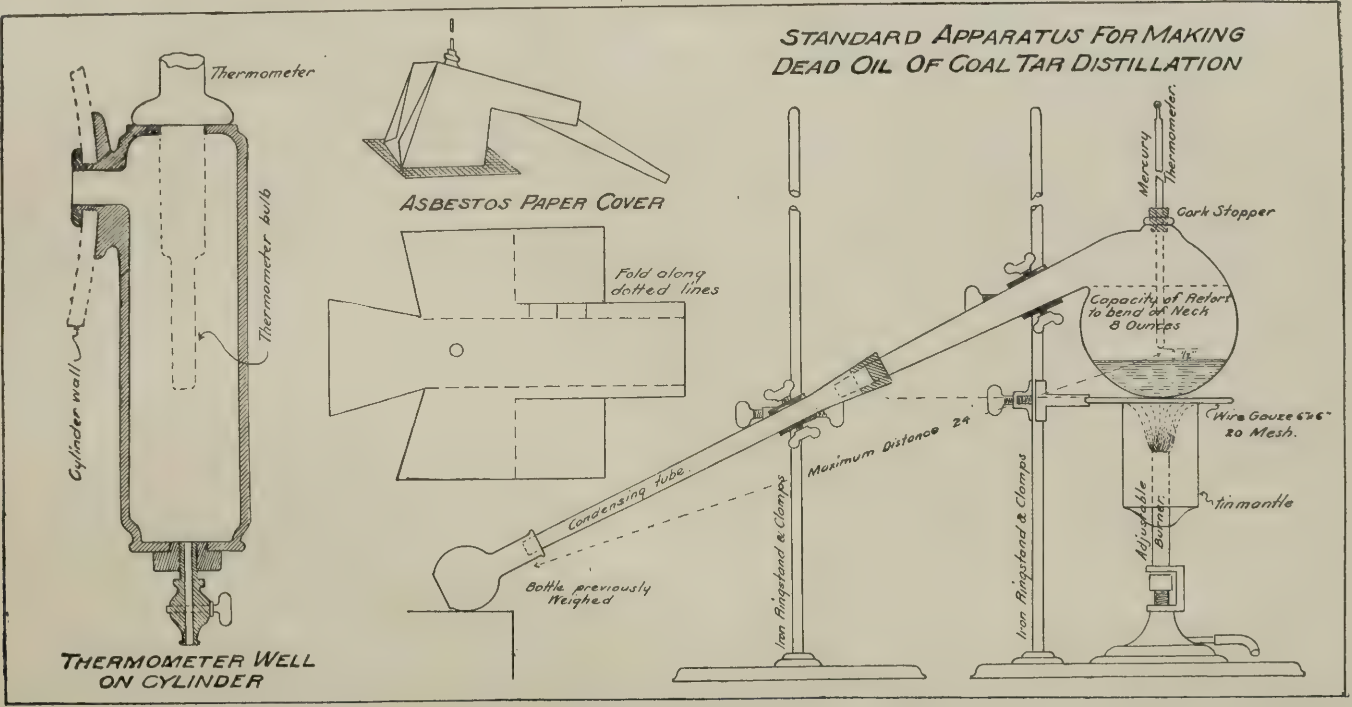
It shall be subject to a distilling test as follows:

4. The sample taken for analysis shall be strictly average of the whole bulk of oil to be tested. The oil shall be completely liquefied and well mixed before any samples are taken. Whenever possible, a drip sample of not less than two gallons shall be taken, commencing after the oil has started to run freely. Where this cannot be done, as, for instance, in large storage tanks, samples shall be taken from various depths in the tank by means of a tube or bottle, the number of samples depending on local conditions.

For taking samples during the process of treatment a sample of the oil shall be taken from the storage tank about one foot from the bottom of the tank before the cylinder is filled, and when possible a sample directly from the cylinder during the process of treatment. For this purpose a thermometer well, as shown in diagram, may be used.

The sample to be analyzed shall be thoroughly liquefied by heating until no crystals adhere to a glass stirring rod, and also well shaken, after which one-half shall be taken for analysis and the balance reserved as a check test.

5. The apparatus for distilling the creosote oil shall consist of a stoppered glass retort similar to that shown in diagram, having a capacity as nearly as can be obtained of eight ounces up to the bend of the neck when the bottom of the retort and the mouth of the off-take are in the same plane. A nitrogen filled mercury thermometer of good standard make, divided into full degrees centigrade, shall be used in connection therewith, placed with the bulb one-half (½) in. above the surface of the oil. In order to insure uniform results for comparative purposes,



THERMOMETER WELL ON CYLINDER

ASBESTOS PAPER COVER

STANDARD APPARATUS FOR MAKING DEAD OIL OF COAL TAR DISTILLATION the length of the thermometer bulb shall be one-half inch; but in no case shall a thermometer with a long bulb be used. The bulb of the retort and at least 2 in. of the neck shall be and remain covered with a shield of heavy asbestos paper, shaped as shown in diagram, during the entire process of distillation, so as to prevent heat radiation, and between the bottom of the retort and the flame of the lamp or burner two sheets of wire gauze, each 20-mesh fine, and at least 6 in. square, shall be placed.

The flame shall be protected against air currents. An ordinary tin can, from which a portion of the bottom and all of the top have been removed, placed on a support attached to the burner, as shown in diagram, will answer the purpose.

6. Before beginning the distillation the retort shall be carefully weighed and exactly one hundred grammes of oil placed therein, the same being weighed in the retort. The thermometer shall be inserted in the retort with the lower end of the bulb one-half inch from the surface of the oil and the condensing tube attached to the retort by a tight cork joint. The distance between the bulb of the thermometer and the end of the condensing tube shall not be less than 20 nor more than 24 in., and during the progress of the distillation the thermometer shall remain in the position originally placed.

The distillate shall be collected in weighed bottles and all fractions determined by weight on the basis of the dry weight of the oil. Reports shall be made on the following fractions:

0 to 170 degrees Centigrade.
170 to 200 degrees Centigrade.
200 to 210 degrees Centigrade.
210 to 235 degrees Centigrade.
235 to 270 degrees Centigrade.
270 to 315 degrees Centigrade.
315 to 355 degrees Centigrade.
Residue above 355 degrees Centigrade.

Reports shall be made on individual fractions. In making such reports it is to be distinctly understood that these fractions do not necessarily refer to individual compounds. In other words, the fraction between 210 and 235 degrees will not necessarily be all naphthalene, but will probably contain a number of other compounds.

The distillation shall be a continuous one, and at the rate of one or two drops per second.

When any measurable quantity of water is present in the oil, the distillation shall be stopped, the oil separated from the water and returned to the retort, when the distillation shall be recommenced and the previous readings discarded. In obtaining water-free oil, it is desirable to free about 300 to 600 cc. of the oil by using a large retort and using 100 grammes of the water-free oil for the final distillation. In the final report as to fractions, a correction shall be made of the amount of water remaining, so that the report may be made on the basis of a dry oil.

Tested in the above manner, it shall give:

No distillate up to 200 degrees C.
Less than 5 per cent. up to 210 degrees C.
Less than 25 per cent. up to 235 degrees C.

7. The distillate between 210 and 235 degrees C. shall deposit naphthalene salts on cooling to room temperature (20 degrees C.). The distillate between 315 and 355 degrees C. shall yield solids on cooling to room temperature. During distillation, the oil shall not show any evidence of decomposition, as indicated by the presence of dense white fumes in the condenser.

8. The oil shall not contain more than three (3) per cent. of water.

9. In order to determine the specific gravity of any oil, simply heat the oil in a water bath until it is completely liquid. A glass stirring rod dipped into the liquid should show no solid particle on the rod when the same is withdrawn from the oil. When completely liquid, stir thoroughly and fill the hydrometer cylinder, which has previously been warmed. Insert a specific gravity hydrometer of good make, taking care that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken. This reading should preferably be taken when the oil is at 38 degrees Centigrade (100 degrees Fahrenheit), because at this temperature almost all oils are completely fluid. Where contract requirements specify a specific gravity at a different temperature, such gravity is obtained by multiplying .0008 by the number of degrees Centigrade, or .00044 by the number of degrees Fahrenheit, the oil is found to be above the temperature required by the contract, and adding the product to the observed gravity.

The following discussion of the preceding specification indicates the reasons for recommending the specification as revised, the numbering referring to the corresponding numbers in the specification:

Paragraph 1. The preamble specifies clearly the same kind of oil as is allowed under the previous standard, including all sources that are allowed under it, and excluding everything that is there excluded. However, one or two objections to the previous form are entirely avoided. The previous standard admits of using only high-grade coal-tar creosote, or, in other words, such oil as is derived by the distillation of coal-gas tar or coke-oven tar. It admits of the admixture of no other oil from any source whatever, nor of any other tar except coal tar. Since it is permissible to add to the creosote a small proportion of such coal tar as is low in carbon, it is believed more proper and preferable to state that "the creosote oil shall be definite as a product obtained entirely from," etc., instead of saying that "it must be a pure product of coal-tar distillation."

Paragraph 2. No commercial creosote used for wood preservation is entirely free from insoluble matter. It is well known that where an oil is used repeatedly in the treatment of successive charges of ties or timber, there occurs a constant accumulation of insoluble matter. It is hardly necessary to state that in placing the limit of 2 per cent. on insoluble matter, no new departure is contemplated. It is merely one step in writing a specification, the requirements of which will be definitely stated and serve as nearly as possible to enforce the oil specified.

Paragraph 3. In order to guard against such unduly heavy oils as are unsuited to the treatment of ties and timbers, there should be a definite maximum limit on the specific gravity of oil allowed. This is just as important as a low limit, and is thoroughly in accord with the practice abroad. The standards used abroad are limited pretty generally to 1.08 at 25 or 38 degrees C. In this country, it is almost unanimously agreed that 1.10 specific gravity at 20 or 25 degrees C. is quite heavy enough for use on paving blocks. In the treatment of ties and timber, where depth of penetration is of greater importance than increased resistance to absorption of moisture, the oil should certainly be decidedly lighter than a paving oil.

Your Committee acknowledges the valuable services rendered in the preparation of this specification by Mr. H. M. Newton, Chief Chemist, The Kettle River Company, and Mr. Ernest Bateman, Chemist, Forest Products Laboratory.

USE OF TIE-DATING NAILS.

For the purposes desired in connection with the work of the Wood Preservation Committee, the insertion of dating nails in all ties and the keeping of a record of the life of all ties is believed to be unnecessary, as, in the first place, accurate records of all ties cannot be obtained on account of depending on the various section foremen for the information. Such a practice also entails a very considerable expense for dating nails, applying same and keeping records, which expense is considered unnecessary. Furthermore, it is considered desirable to keep record of the information in more detail than would be practicable if a record were kept of all ties used, it being desirable that the records should show not only the process of treatment, but should also indicate the kind of wood in each case and the details of the particular treatment for the individual ties.

For the purposes of the Wood Preservation Committee, therefore, it is recommended that paragraph 12 in the Revised Manual be supplemented by the following:

12. For best results it is recommended that certain sections of track be selected on each railroad for the purpose of making accurate tests covering the life of treated and untreated ties of various kinds of timber and under various treatments, and that an accurate record be kept of the life of all ties in these test sections of track in order to be able hereafter to improve on the treatment. All ties inserted in such test sections shall be marked with dating nails, and, if necessary, with other identification marks.

GENERAL REMARKS.

It is not seen fit to make any further changes in the Manual than those listed above, except that the term "creosote oil" shall be used in all cases in preference to "coal-tar creosote," "coal tar" or "dead oil," etc.

Appendix B.

REPORT OF SUB-COMMITTEE ON "SPECIFICATIONS."

The instruction of the Board of Direction to the Committee on Wood Preservation provides that it shall "extend specifications for timber treatment to include Rueping, Lowry and other widely used processes." After careful consideration and discussion, the Sub-Committee makes the following recommendations:

(1) That no mention should be made in the Manual of any patented process, but that the descriptions be published in the Proceedings of the Association.

(2) That it is not desirable to prepare "specifications" covering patented processes; "descriptions" have therefore been substituted in place of "specifications."

(3) That the descriptions of the various patented processes shall be purely descriptions of the process, and shall not contain claims as to the efficiency of the treatment.

(4) That the Allardyce process, being not patented and practically conforming to the "Two-Injection Zinc Creosote Treatment," as now covered in the Manual, should not be duplicated in this report, and the term "Two-Injection Zinc Creosote Treatment" should be used in the Manual as heretofore.

With these points in mind, the following descriptions of various widely used processes are submitted:

These descriptions are submitted by the patentees as properly covering their processes. The Committee assumes no responsibility in the matter, except that it believes each description represents with reasonable correctness the process as actually practiced.

DESCRIPTION OF THE CARD PROCESS.

This process is covered by Patent No. 815404, dated March 20, 1906, issued to J. B. Card.

(1) Timber to be thoroughly air seasoned.

(2) Vacuum of from 22 inches to 26 inches for one hour.

(3) Liquid admitted at temperature of not less than 180 degrees and a pressure of 125 lbs. per sq. in. obtained and held from three to five hours.

(4) Final vacuum to dry off ties.

Solution.

Usually 80 per cent. of the solution of chloride of zinc and 20 per cent. of creosote oil. The chloride solution shall be of sufficient strength to allow an average of ½ lb. of dry chloride of zinc to be injected into the wood.

Mixing the Solution.

In order to keep the chloride of zinc solution and creosote oil thoroughly mixed during the process of treatment, it is first agitated in the measuring tank by forcing air through pipes into the liquid. When thoroughly mixed, it is admitted to the cylinder, and there continually agitated by a centrifugal pump drawing the liquid from the top of the cylinder at three points—the center, and each end. After passing into the centrifugal pump, the liquid is discharged through a pipe which lies along the full length of the bottom of the cylinder, and is perforated throughout its length. This pump should handle about 1,500 gallons a minute.

If it is desired to treat material that is not fully seasoned, a previous steaming can be used the same as in any other process. The only difference between this and other full-cell processes is the agitating of the liquid to keep the two constituents mixed.

DESCRIPTION OF THE LOWRY PROCESS.

This process is covered by Patent No. 831450, issued to C. B. Lowry under date of September 18, 1906.

Air-seasoned timber of the same species, density and moisture content is loaded on tram cars and placed within the retort. The retort is then filled from the charging tank with creosote oil at a temperature not to exceed 200 degrees Fahrenheit. The main line is then closed and oil from the charging tank is forced by pressure pumps into the retort until the timber has taken oil to the point of refusal, or a predetermined amount. The pressure and temperature within the retort are controlled so as to give a maximum penetration of the oil. The pressure is then released and the free oil in the retort is drained off. A vacuum of sufficient degree and duration is then drawn in the retort to recover that portion of the free oil in the timber above the specified amount. The recovered oil is then drained off from the retort and the charge is withdrawn.

DESCRIPTION FOR TREATMENT OF GREEN OR WATER-SOAKED TIMBER.

BUEHLER PROCESS.

This process is covered by Patent No. 899237, issued under date of September 22, 1908, to Walter Buehler.

Each cylinder charge must be made up of timbers of practically the same dimensions. Seasoned and green or freshly sawed material must not be mixed together and treated in the same charge.

Dimension timber must not be treated in the same charge with planking, nor ties with planking, and sufficient 1-in. strips must be placed between each tier of sawed ties or timbers with ½-in. space left between each piece so that the oil can have free access to all surfaces.

After the timber has been placed in the cylinder, it must be immersed in creosote oil of a temperature not less than 140 degrees F. and kept covered during the entire seasoning period. The engineer on duty must from time to time during the seasoning period satisfy himself by bleeding the cylinder that such is the case.

After filling the cylinder with oil, steam must then be regulated through the heating coils so that the temperature within the cylinder is kept gradually rising as fast as the condensation will permit until a temperature between 220 and 260 degrees F. is reached, the exact temperature dependent upon the size and character of the timber, after which the steam pressure must only be such as to maintain a regular and constant temperature within the cylinder at the maximum temperature allowable for the timber being treated. During the seasoning period a gage on the cylinder should show a pressure of not more than 5 lbs. The maximum temperature shall be maintained until the condensation collecting in the hot well shows the interior of the wood to be sufficiently dry, or when condensation does not exceed one-sixth of a pound of water per cubic foot of charge, when the steam pressure in the coils should be released and the cylinder filled up with creosote oil from the measuring tank, the temperature allowed to reduce until a temperature of about 200 degrees is obtained, the pump pressure applied until the timber has taken the proper amount of oil.

After the proper quantity of oil has been injected, the cylinder shall be drained and an air pressure of not less than 15 or more than 25 lbs. be maintained within the cylinder for a sufficient length of time to thoroughly penetrate with air all of the ties or timbers.

The measurement of the oil in each charge, four gage readings shall be taken.

First, gage of measuring tank from which oil is to be taken before any oil has been admitted to the cylinder.

Second, gage reading of measuring tank after oil has been admitted to the cylinder and the same completely filled.

Third, gage reading after the required amount of oil has been injected.

Fourth, gage reading after the oil in the cylinder has been returned to the measuring tank. Temperature of oil shall be taken before it enters or as it enters the cylinder and during the treatment, and as it leaves or after it has been returned to the measuring tank. A correction for temperature shall be made on each charge. The difference between the first gage reading and the fourth gage reading with a proper temperature correction shall be the amount of oil injected. It is required that the amount of oil injected shall be measured before the ties or timbers are withdrawn from the cylinder, and if proper quantity of oil has not been injected, the oil is to be returned to the cylinder and the deficiency made up.

DESCRIPTION FOR TREATMENT OF SEASONED TIMBER. BUEHLER PROCESS.

This process is covered by Patent No. 899480, issued under date of September 22, 1908, to Walter Buehler.

After ties are placed in the cylinder, the vacuum shall be drawn, until a minimum of 20 in. is obtained, which vacuum shall be maintained for at least 20 minutes. After the vacuum has been maintained as above, creosote oil shall be admitted into the cylinder until the ties are completely filled. Pressure shall then be applied and maintained until the proper amount of oil has been injected.

After the proper quantity of oil has been injected, the cylinder shall be drained and an air pressure of not less than 15 nor more than 25 lbs. be maintained within the cylinder until the maximum pressure remains constant for at least 15 minutes.

For the measurement of oil in each charge, four gage readings shall be taken.

First, gage of measuring tank from which the oil is to be taken before any oil has been admitted to the cylinder.

Second, gage reading of the measuring tank after oil has been admitted to the cylinder and the same completely filled.

Third, gage reading after the required amount of oil has been injected.

Fourth, gage reading after the oil in the cylinder has been returned to the measuring tank. Temperature of the oil shall be taken before it enters or as it enters the cylinder and during the treatment, and as it leaves or after it has been returned to the measuring tank.

A correction for temperature shall be made on each charge. The difference between the first reading and the fourth gage reading, with a proper temperature correction, shall be the amount of oil injected. It is required that the amount of oil injected shall be measured before ties are withdrawn from the cylinder, and if proper quantity of oil has not been injected, the oil is to be returned to the cylinder and the deficiency made up.

DESCRIPTION OF THE BOILING PROCESS.

This process, together with certain details of construction, was patented by the late William G. Curtis and John D. Isaacs. The process patent number was Reissued No. 11,515, dated November 1, 1895.

The description covers the treatment of piling and sawn timber of all kinds and dimensions.

Piling.

The piles are placed on trucks in closed treating cylinders and immersed in creosote oil heated to a temperature of about 160 degrees Fahrenheit. A space of about 10 in. is left clear from the top of the oil to the top of the treating cylinder. Steam is then admitted into the heating coils and the temperature of the creosote gradually raised to 212 degrees Fahrenheit. The vapors passing over are condensed in a surface condenser. The temperature is gradually raised until a maximum of 225 degrees Fahrenheit is reached, and this temperature is maintained until the rate of evaporation does not exceed one-sixth of a pound of water per cubic foot of material in the charge.

The treating cylinder is next filled with creosote oil at a pressure of 5 lbs. on the pump gauge, the temperature falling to about 200 degrees Fahrenheit. The pressure pump is then started and pressure applied until such time as the required amount of creosote oil shall have been injected into the timber. (In the Southern Pacific plant the pressure does not exceed 140 lbs. per sq. in.) After injection the pressure is slowly released through an overflow pipe, the creosote oil drawn off from the treating cylinders, and the charge removed. (In the Pacific Creosoting plant this is not done until the temperature of the charge has been reduced to 200 degrees Fahrenheit.) The piles, upon coming from the treating cylinder, should be free from heat checks. The borings should be dry, and beyond the penetration of the creosote, should retain their natural elasticity.

Timber.

In treating dry sawn timber it is advisable not to exceed 212 to 214 degrees Fahrenheit, or 120 pounds pressure. Otherwise the process is the same as the above.

DESCRIPTION OF RUEPING PROCESS.

The patent covering the Rueping method of impregnating wood was issued under Patent No. 709,799, dated September 23, 1902, to Messrs. Hulsberg & Co., M. B. H., of Germany, and reissued to same company October 22, 1907, under Patent No. 12,707.

Seasoned Timber.

1. The timber to be treated should preferably be thoroughly air-seasoned. Green, or partially seasoned, timber must be steam-dried before treatment.

Air Pressure.

2. The timber is subjected to an initial air or gas pressure in the receptacle, until all the cells and cavities of the wood are filled, after which, while maintaining the air pressure, the impregnating liquid, under a still higher pressure, is introduced into the receptacle, in which the material treated is placed. In most cases the compressed air is introduced direct from the compressor, which operation generally takes sufficient time for the wood to be thoroughly saturated with compressed air. If the compressed air is introduced into the treating cylinder direct from the air accumulator, and thus fills the receptacle in a short time, the second step of the operation should not be begun until the wood has been exposed to the full influence of the compressed air, for sufficient time for the air to fill all the cells and cavities of the wood. In proportion to the quantity of impregnating liquid entering the receptacle, air is allowed to escape in order to make room for the required quantity of liquid.

Location of Air Escape Valve.

3. While the impregnating liquid is being introduced into the treating cylinder, the air pressure must be on an even level, and sufficient liquid must be introduced to completely fill the cylinder. For this reason the air escape valve must be at the highest point of the cylinder to avoid air pockets from forming in the liquid.

Impregnating Liquid Pressure.

4. The material being completely covered with the liquid, pressure is raised by introducing additional quantities of impregnating liquid until the pressure has reached the desired height to fully penetrate the cells of the wood. It is desirable that this pressure be increased slowly and in regular stages until the maximum has been reached.

Amount of Liquid Absorbed.

5. The maximum pressure of the impregnating liquid must be maintained until the timber will not absorb any more appreciable quantity of the liquid. The pressure is then cut off, and the impregnating liquid is discharged. It is not necessary to limit, in any way, the gross absorption of the timber; in fact, it is essential that no limit be placed on same, so that the certainty is established that all parts of the timber which will take treatment are reached by the impregnating liquid. If, after the end of the run, it is shown that the final absorption is too large, then either the initial air pressure may be increased or the liquid pressure decreassed, or, if too small, the air pressure may be decreased, or the liquid pressure may be increased.

Regulating Impregnating Liquid Absorption.

6. The final absorption is dependent on the relative differences between the air pressure and the impregnating liquid pressure, and by regulating the comparative heights of these pressures the final absorption can be adjusted to the specified, or desired, quantities. When experimenting which are the correct pressures to use on a particular lot of timber, it is advisable to keep the liquid pressure at an even height, and raise or reduce the air pressure, rather than vary the liquid pressure, while the air pressure is maintained evenly. Should, however, neither of these methods bring about quick and desired results, then both air and liquid pressures may be raised or lowered at the same time.

Time Required for Absorption.

7. If the high impregnating liquid pressure is resorted to, it does not have to be kept on the wood the same length of time as a small one, for at a higher pressure the liquid will penetrate the timber to its maximum absorption much quicker.

Object In Use of Vacuum.

8. The main object of the vacuum, which tends to increase the expansion force of the compressed air in the timber, is to dry the timber from surface adhesion of the preservative. If it is at all possible, the vacuum shall be maintained until at least in the surface sections of the timber atmospheric or less pressure is established, so that the timber leaves the cylinder dry, and the escape of the compressed air, which will take place during the next hour or so, will not cause dripping.

Appendix C.

REPORT OF THE SUB-COMMITTEE ON GROUPING TIES FOR TREATMENT.

The Sub-Committee was instructed to carry on still further its investigation on the proper grouping of ties for treatment and to encourage such experiments at commercial treating plants. A circular letter was sent to representative plants asking for their co-operation in conducting tests along the following lines:

(1) To treat ties when seasoned to various weights per cubic foot, using their standard process; the object being to determine the proper treating weight of ties.

(2) To separate ties into heartwood and sapwood groups, noting the absorption and penetration obtained for each; the object being to determine the advisability of separating ties for treatment.

(3) To treat separately ties grown in widely different geographical regions; the object being to determine the advisability of differentiating in the commercial treatment of such ties.

Many of the companies written to signify their readiness to co-operate with the Association in this work, and accordingly experiments on the above either are or will be put under way at the following plants:

Chicago Tie and Timber Preserving Company.
Gulfport Creosoting Company.
International Creosoting and Construction Company.
The Kettle River Company.
Northern Pacific Railway Company.
Pennsylvania Railroad Company.
Texas Tie and Lumber Preserving Company.

In addition, investigations on the resistance of the more important commercial American woods to injection with creosote and zinc-chloride are now well under way at the Forest Products Laboratory, Madison, Wis

As this work is in a formative stage at present, no final results can be reported until next year. The following information has, however, been secured:

Northern hard maple ties seasoned for eighteen months at the plant of the Chicago Tie and Timber Preserving Company, Waukegan, Ill., treated by the Card process (zinc strengths 3.2 per cent., creosote in solution 16 per cent., pressure 125 lbs. per square inch applied four hours, initial vacuum 26 inches applied thirty minutes) gave the following results:

Class.	Av. weight per tie (lbs.)	Av. weight per cu. ft. (lbs.)	Av. absorption (lbs.)		Vol. tie cu. ft.
			Per tie.	Per cu. ft.	
Heart......	189.8	48.2	64.9	16.5	3.94
Sap........	179.3	45.5	72.9	21.0	3.94

In regard to the separation of sap and heartwood for pine ties, Mr. George E. Rex, President of the Texas Tie and Lumber Preserving Company, states:

"Our ties are piled in long tracks, say 150 piles to the track, with 1,000 ties in a pile. When the ties are properly seasoned 60 or 70 tram cars at a time are run opposite these piles, loaded and treated. In this first shove of the track we pick up the heart ties in the piles, dropping the saps to one side. The next shove we pick up the saps. In this manner we find we can get the separation done pretty satisfactorily with no additional cost."

Appendix D.

REPORT OF SUB-COMMITTEE ON SPECIFICATIONS FOR PILES TO BE TREATED.

General Requirements.

1. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects which may materially impair their strength.

2. Piles must be butt-cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile. Diameter of piling should be ascertained by measuring the circumference and dividing by the number 3.14 in all cases where the tree is not practically round.

3. Piles must not exceed twenty (20) in. in diameter at any point; that is, swollen butts and projecting knots must be trimmed so that the diameter will not exceed twenty (20) in.

4. All knots shall be trimmed close to the body of the pile and the bark peeled, including the inner skin, so that the piles are practically smooth and clean.

5. Piles of different timbers must be delivered in separate lots.

6. Piles with a large amount of sap wood are to be preferred.

PILES.

Southern Yellow Pine.

Shall be of any variety of Southern Yellow Pine. For round piles the minimum diameter at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft., eight (8) in. for lengths over thirty (30) ft., but not exceeding fifty (50) ft. The minimum diameter at one-quarter of the length from the butt shall be twelve (12) in., and the maximum diameter at the butt twenty (20) in.

White Cypress.

Shall be not less than 12 in. in diameter at the tip for piles 30 ft. long, nor less than 10 in. in diameter for piles 30 to 40 ft. long, inclusive, and not less than 9 in. in diameter for piles over 40 ft. long.

Red Oak.

May be of red oak, willow oak, black oak, pin oak or water oak.

Shall not be less than 12 in. in diameter, 6 ft. from butt, and not less than 10 in. in diameter at the tip for piles under 30 ft. long; not less than 9 in. in diameter for piles 30 to 39 ft. long, and not less than 8 in. in diameter for piles over 40 ft. long.

Douglas Fir.

Shall be either red or yellow Douglas Fir. Piles shall not be less than 14 in. and not more than 18 in. in diameter at the butt and not less than 10 in. in diameter at the tip for piles forty (40) ft. or less in length. Piles over forty (40) ft. in length shall not be less than sixteen (16) in. or more than twenty (20) in. in diameter at the butt and not less than eight (8) in. in diameter at the tip.

SPECIFICATIONS FOR BRIDGE MATERIAL TO BE TREATED.

General Requirements.

Except as noted, all timber shall be sound, sawed standard size, full length, square cornered and straight; free from defects, such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, large pitch pockets or other defects that will materially impair its strength. Sapwood no objection.

Standard Size of Sawed Timbers.

Rough timbers when sawed to be standard size shall not be over ¼-in. scant from actual size specified.

Standard Dressing of Sawed Timbers.

Standard dressing means that not more than ¼-in. shall be allowed from dressing each surface. For instance, a 12-in x 12-in shall, after dressing four sides, measure not less than 11½ in. x 11½ in.

STRINGERS.

Southern Yellow Pine (to include long-leaf, short-leaf and loblolly pines).

Timbers shall show at least an average of eight annual rings per inch, the average to be determined by the measurement of at least four inches as measured from the center of the stick outward.* Knots greater than one and one-half (1½) in. in diameter will not be permitted at any section within four (4) in. of the edge of the piece, but knots shall in no case exceed four (4) in. in their largest diameter.

Douglas Fir.

Shall be of dense growth, showing an average of not less than twelve annual growth rings to the inch. Shall be out of wind and free from shakes, splits or pitch pockets over three-eighths (⅜) in. wide or five (5) in. long. Knots greater than two (2) in. in diameter will not be permitted within one-fourth (¼) of the depth of the stringer from any corner nor upon the edge of the piece; knots shall in no case exceed three (3) in. in diameter.

CAPS, SILLS, POSTS, GUARD RAILS, LONGITUDINAL STRUTS AND GIRTS.

Southern Yellow Pine (to include long-leaf, short-leaf and loblolly pines).

Timbers shall show at least an average of eight annual rings per inch, the average to be determined by the measurement of at least four (4) in., as measured from the center of the stick outward; caps, sills and posts must be free from knots over two and one-half (2½) in. in diameter; guard rails, longitudinal struts and girts shall be free from any large knots or other defects that will materially injure their strength.

CAPS, SILLS AND POSTS.

Douglas Fir.

Shall be out of wind and free from shakes, splits and pitch pockets over one-half (½) in. wide or five (5) in. long. Knots shall not exceed one-fourth (¼) of the width of the surface of the piece in which they occur, and shall in no case exceed three (3) in. in diameter.

*Note.—The Committee has spent much time endeavoring to formulate a specification for the various grades of Southern Yellow Pine. The distinction made by means of the number of rings per inch may not be the best method nor are the specific number of rings per inch to be considered as anything more than a suggestion for discussion and verification. It is probable that no general figure can be given, because different railroads use structural timbers under such varying conditions of service. With the admission of the sap pines, it is imperative that a lower limit of rings per inch be specified to insure strong wood for bearing and framing. The Committee presents these figures for the purpose of discussion and obtaining information and suggestions which may make the formulations of an acceptable specification possible. This note refers to all references to the question of number of rings per inch in these specifications.

Referring to the treatment of Bridge Materials, the Committee recommends the adoption of a clause to be added to the specifications for treatment, dealing with the subject of the framing of timbers before treatment. It is of the greatest importance that all bridge timbers be framed, including the boring of holes, before treatment, so that any injury to timbers after treatment be avoided. The Committee would accordingly suggest the incorporation of the following clause in the specifications for treatment:

"All Bridge Material intended for treatment should be framed, as far as possible, before timbers are placed in the treating cylinder. This includes the boring of the necessary holes."

Appendix E.

STATISTICS.

*CROSS-TIES PURCHASED: 1909.

The total number of wooden cross-ties purchased by the steam and electric railroads of the United States in 1909 was 123,751,000. This represents an increase of 11,285,000 ties, or 10 per cent. over the number purchased in 1908, but a decrease of 29,952,000, or 19.5 per cent., from the number reported for 1907. The year 1907 was one of great activity in the railroad world, while in 1908 the railroads felt the effect of the general business depression and curtailed their expenses accordingly. From a comparison of the figures for 1909, 1908 and 1907, it is evident, however, that the cross-tie industry is rapidly regaining the prosperity enjoyed in 1907.

The figures covering the ties purchased for new track are likewise significant of improvement. Nearly 16,437,000 ties, or 13.3 per cent. of the total number, were reported as purchased for new track in 1909, whereas in 1908 only 7,431,000 ties, or 6.6 per cent. of the total purchased, were for this use. In 1907 the number was 23,557,000, or 15.3 per cent. of the total. Of the ties bought for new track in 1909, the steam railroads reported 13,822,000, or about 84 per cent., and the electric roads 2,615,000. The ties purchased for new track by steam roads formed 12 per cent. of all ties purchased by them, while the corresponding proportion for the electric roads was 31.4 per cent. The steam roads, however, showed by far the larger relative gain over 1908 in this respect, since their building activities were restricted during the latter year to a greater extent than was the case with the electric lines.

Table 1 gives the number of ties purchased in 1909, 1908 and 1907, distributed according to class of ties and kind of wood.

Ten kinds of wood supplied 97.3 per cent. of all ties purchased. These are oak, Southern pine, Douglas fir, Western pine, cedar, chestnut, cypress, tamarack, hemlock and redwood. The oaks led by a wide margin, being the timber used for 57,132,000 ties, or 46.2 per cent. of the total number purchased, and more than two and one-half times as many ties as were made from the Southern pines, which ranked next in importance and which were used in the production of 21,385,000 ties. More than 63 per cent. of all ties purchased were made from some species of oak or from the Southern yellow pines.

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*Authority, Bureau of the Census, in co-operation with the Forest Service.

TABLE 1.—CROSS-TIES PURCHASED, CLASSIFIED ACCORDING TO METHOD BY WHICH MADE AND KIND OF WOOD: 1909, 1908 AND 1907.

Kind of Wood.	Total.	Hewed.	Sawed.
1909.			
Total	123,751,000	95,499,000	28,252,000
Oak	57,132,000	48,009,000	9,123,000
Southern pine	21,385,000	17,452,000	3,933,000
Douglas fir	9,067,000	1,952,000	7,115,000
Western pine	6,797,000	4,466,000	2,331,000
Cedar	6,777,000	4,964,000	1,813,000
Chestnut	6,629,000	5,026,000	1,603,000
Cypress	4,589,000	3,994,000	595,000
Tamarack	3,311,000	2,981,000	330,000
Hemlock	2,642,000	2,215,000	427,000
Redwood	2,088,000	1,770,000	318,000
White pine	556,000	179,000	377,000
Lodgepole pine	487,000	459,000	28,000
Gum	378,000	332,000	46,000
Spruce	225,000	155,000	70,000
Beech	195,000	163,000	32,000
All other	1,493,000	1,382,000	111,000
1908.			
Total	112,466,000	91,982,000	20,484,000
Oak	48,110,000	42,143,000	5,967,000
Southern pine	21,530,000	18,556,000	2,974,000
Douglas fir	7,988,000	1,946,000	6,042,000
Western pine	3,093,000	2,140,000	953,000
Cedar	8,172,000	7,469,000	703,000
Chestnut	8,074,000	5,400,000	2,674,000
Cypress	3,457,000	3,091,000	366,000
Tamarack	4,025,000	3,806,000	219,000
Hemlock	3,120,000	3,036,000	84,000
Redwood	871,000	757,000	114,000
White pine	707,000	565,000	142,000
Lodgepole pine	518,000	487,000	31,000
Gum	262,000	262,000	....
Spruce	141,000	83,000	58,000
Beech	192,000	191,000	1,000
All other	2,206,000	2,050,000	156,000
1907.			
Total	153,703,000	118,385,000	35,318,000
Oak	61,757,000	53,702,000	8,055,000
Southern pine	34,215,000	26,227,000	7,988,000
Douglas fir	14,525,000	1,631,000	12,894,000
Western pine	5,019,000	3,255,000	1,764,000
Cedar	8,954,000	8,362,000	592,000
Chestnut	7,851,000	6,330,000	1,521,000
Cypress	6,780,000	5,881,000	899,000
Tamarack	4,562,000	4,152,000	410,000
Hemlock	2,367,000	2,288,000	79,000
Redwood	2,032,000	1,485,000	547,000
White pine	475,000	294,000	181,000
Lodgepole pine	667,000	667,000	....
Gum	15,000	15,000	....
Spruce	104,000	24,000	80,000
Beech	52,000	8,000	44,000
All other	4,328,000	4,064,000	264,000

Douglas fir, a species which will probably be drawn upon heavily as the demand for ties crowds the supply, was used for 9,067,000 ties. Ranking next in importance were Western pine, cedar and chestnut, each being credited with a total of slightly more than 6,500,000 ties. Cypress, tamarack, hemlock and redwood each supplying more than 2,000,000 ties, complete the list of the ten leading kinds of wood purchased. The remaining species, which include white pine, lodgepole pine, gum, spruce, beech, maple, birch, elm, mesquite, locust, ash, walnut and a number of others, furnished but 3,334,000 ties.

The two leading timbers were the same as in 1908. Oak, with an increase of 9,022,000 ties, contributed a slightly higher proportion of the total number of ties purchased in 1909 than in 1908. Southern pine, on the other hand, furnished a slightly smaller number of ties than in 1908 and a smaller proportion of the total. Douglas fir, with an increase of 1,079,000 ties, held third rank in 1909, the same as in 1907.

Western pine was the only one of the ten leading kinds of wood which showed a marked increase over the figures for 1907, the year for which the heaviest purchases of ties were recorded. Hemlock supplied more ties in 1908 than in 1907, but fewer in 1909 than in 1908. The purchase of 2,088,000 redwood ties in 1909 is the heaviest recorded for this timber, being slightly greater than in 1907 and exceeding that of 1908 by 1,217,000 ties.

The increasing use of several of the relatively unimportant tie woods, especially gum, spruce and beech, is noteworthy. The number of gum ties purchased, which in 1907 was only 15,000, increased to 262,000 in 1908, and by a further gain of 116,000 ties reached a total of 378,000 ties in 1909. Spruce and beech also showed heavy gains during the past two years. The increasing use of these species which are lacking in decay-resisting qualities is evidence of the growing use of methods of wood preservation through chemical treatment.

Approximately 77 per cent. of all ties purchased in 1909 were hewed. Although the proportion of hewed ties was lower than in 1908, it was the same as in 1907 and higher than in 1906. About 82 per cent. of all ties purchased in 1908 and about 75 per cent. of those purchased in 1906 were hewed. In the industry as a whole it is apparent that methods of manufacture are not undergoing any great general and permanent changes.

Cross-ties made of oak showed a slight gain in the relative number of sawed ties. In 1908, 12.4 per cent. of the oak ties purchased were sawed, while in 1909 16 per cent. were so reported. In the case of ties made from Southern pine the proportion of hewed ties, although less than in 1908, was greater than in 1907. Douglas fir is the only important timber from which more ties are sawed than hewed, 78.5 per cent. of the ties reported as made from this timber in 1909 being sawed. The number of ties hewed from Douglas fir does not change from year to year proportionate to the use of the species, the fluctuations in the demand for ties made from this wood being confined largely to sawed ties, which show wide variations annually.

In the case of cedar ties the number of hewed ties shows a steady and heavy decrease since 1907, while the number of sawed ties has increased correspondingly, from 592,000 in 1907 to 1,813,000 in 1909.

Table 2 shows the number and cost of ties purchased by steam and electric railroads of the United States in 1909, classified according to kind of wood and method by which made.

The steam railroads of the United States purchased 115,432,000 cross-ties in 1909, or 93.3 per cent. of the total quantity purchased. Of these 77.9 per cent. were hewed and 22.1 per cent. sawed. The electric railroads purchased 8,319,000 ties, or 6.7 per cent. of the total in 1909, a gain of 1,894,000 ties over 1908. Of these 67.5 per cent. were hewed and 32.5 per cent. sawed.

Next to oak ties the electric roads purchased more ties made of chestnut than of any other species. Almost as many Southern pine ties were reported by them; and ties of cedar, redwood and Douglas fir ranked next in importance. Since the steam roads purchased a very high proportion of the total number of ties reported, the rank of the woods used by them is the same as that discussed under the total number purchased by both classes of roads. The less durable woods are little used by the electric roads, doubtless because these roads lack the facilities for preservative treatment which a number of the large steam railroads now possess.

The total cost of all cross-ties purchased in 1909 was $60,320,700, an amount which exceeds the figures for 1908 by more than $4,000,000.

TABLE 2.—CROSS-TIES PURCHASED—NUMBER AND COST AT POINT OF PURCHASE, BY CLASS OF RAILROAD PURCHASING, METHOD BY WHICH MADE AND KIND OF WOOD: 1909.

Aggregate.

Kind of Wood.	Number.	Cost.	Kind of Wood.	Number.	Cost.
Total......	123,751,000	$60,320,700	Tamarack ...	3,311,000	$1,356,000
			Hemlock	2,642,000	865,000
Oak	57,132,000	29,062,000	Redwood	2,088,000	1,108,000
Southern pine	21,385,000	11,112,000	White pine....	556,000	237,000
Douglas fir....	9,067,000	3,754,000	Lodgepole pine	487,000	224,000
Western pine.	6,797,000	3,619,000	Gum	378,000	198,000
Cedar	6,777,000	3,085,000	Spruce	225,000	109,000
Chestnut	6,629,000	2,947,000	Beech	195,000	68,700
Cypress	4,589,000	1,902,000	All other......	1,493,000	674,000

PURCHASED BY STEAM RAILROADS.

Kind of of Wood.	Total.		Hewed.		Sawed.	
	Number.	Cost.	Number.	Cost.	Number.	Cost.
Total..	115,432,000	$56,139,000	89,884,000	$43,644,000	25,548,000	$12,495,000
Oak	53,843,000	27,292,000	45,565,000	22,885,000	8,278,000	4,407,000
Sou. pine..	20,138,000	10,353,000	16,932,000	8,534,000	3,206,000	1,819,000
Douglas fir	8,520,000	3,561,000	1,919,000	741,000	6,601,000	2,820,000
West. pine	6,730,000	3,584,000	4,443,000	2,483,000	2,287,000	1,101,000
Cedar	6,078,000	2,793,000	4,332,000	1,984,000	1,746,000	809,000
Chestnut .	5,252,000	2,318,000	4,016,000	1,759,000	1,236,000	559,000
Cypress ..	4,379,000	1,816,000	3,814,000	1,548,000	565,000	268,000
Tamar'k ..	3,205,000	1,314,000	2,926,000	1,201,000	279,000	113,000
Hemlock.	2,628,000	861,000	2,201,000	717,000	427,000	144,000
Redwood .	1,420,000	785,000	1,128,000	597,000	292,000	188,000
White pine	503,000	211,000	153,000	56,000	350,000	155,000
L'pole pine	487,000	224,000	459,000	213,000	28,000	11,000
Gum	378,000	198,000	332,000	182,000	46,000	16,000
Spruce ...	217,000	105,000	147,000	74,000	70,000	31,000
Beech	193,000	68,000	161,000	57,000	32,000	11,000
All other..	1,461,000	656,000	1,356,000	613,000	105,000	43,000

PURCHASED BY ELECTRIC RAILROADS.

Total.....	8,319,000	$4,181,700	5,615,000	$2,746,700	2,704,000	$1,435,000
Oak	3,289,000	1,770,000	2,444,000	1,282,000	845,000	488,000
Southern pine	1,247,000	759,000	520,000	259,000	727,000	500,000
Douglas fir...	547,000	193,000	33,000	13,000	514,000	180,000
Western pine	67,000	35,000	23,000	19,000	44,000	16,000
Cedar	699,000	292,000	632,000	266,000	67,000	26,000
Chestnut	1,377,000	629,000	1,010,000	467,000	367,000	162,000
Cypress	210,000	86,000	180,000	72,000	30,000	14,000
Tamarack ...	106,000	42,000	55,000	19,000	51,000	23,000
Hemlock	14,000	4,000	14,000	4,000	....	....
Redwood	668,000	323,000	642,000	313,000	26,000	10,000
White pine...	53,000	26,000	26,000	13,000	27,000	13,000
L'gepole pine	....	....	....	....	....	....
Gum	....	....	....	....	....	....
Spruce	8,000	4,000	8,000	4,000	....	....
Beech	2,000	700	2,000	700	....	....
All other.....	32,000	18,000	26,000	15,000	6,000	3,000

Table 3 shows the average cost of cross-ties purchased by steam and electric railroads in 1909, 1908 and 1907, classified according to method by which made and kind of wood.

TABLE 3.—AVERAGE COST OF CROSS-TIES PURCHASED, BY CLASS OF RAILROAD PURCHASING, METHOD BY WHICH MADE, AND KIND OF WOOD: 1909, 1908 and 1907.

PURCHASED BY STEAM AND ELECTRIC RAILROADS.

Kind of Wood.	Total.			Hewed.			Sawed.		
	1909	1908	1907	1909	1908	1907	1909	1908	1907
Total	$0.49	$0.50	$0.51	$0.49	$0.50	$0.51	$0.49	$0.52	$0.54
Oak	0.51	0.51	0.53	0.50	0.51	0.53	0.54	0.56	0.59
Southern pine......	0.52	0.54	0.54	0.50	0.53	0.51	0.59	0.60	0.62
Douglas fir.........	0.41	0.45	0.47	0.39	0.41	0.42	0.42	0.46	0.48
Western pine.......	0.53	0.51	0.50	0.56	0.48	0.49	0.48	0.57	0.52
Cedar	0.46	0.49	0.50	0.45	0.50	0.50	0.46	0.45	0.49
Chestnut	0.44	0.49	0.48	0.44	0.48	0.48	0.45	0.51	0.48
Cypress	0.41	0.44	0.46	0.41	0.43	0.45	0.47	0.52	0.51
Tamarack	0.41	0.50	0.49	0.41	0.51	0.50	0.41	0.41	0.41
Hemlock	0.33	0.38	0.34	0.33	0.38	0.34	0.34	0.36	0.44
Redwood	0.53	0.51	0.59	0.51	0.49	0.60	0.62	0.63	0.57
White pine.........	0.43	0.47	0.41	0.38	0.47	0.37	0.45	0.51	0.47
Lodgepole pine.....	0.46	0.48	0.50	0.47	0.48	0.50	0.39	0.41	.....
Gum	0.52	0.45	0.23	0.55	0.45	0.23	0.34	.....	.....
Spruce	0.49	0.47	0.39	0.51	0.52	0.46	0.44	0.40	0.38
Beech	0.36	0.44	0.40	0.36	0.44	0.34	0.36	0.42	0.41
All other...........	0.45	0.38	0.44	0.45	0.37	0.45	0.41	0.43	0.68

PURCHASED BY STEAM RAILROADS.

Total	$0.49	$0.50	$0.51	$0.49	$0.50	$0.50	$0.49	$0.52	$0.54
Oak	0.51	0.51	0.53	0.50	0.50	0.52	0.53	0.56	0.58
Southern pine......	0.51	0.53	0.53	0.50	0.53	0.51	0.57	0.57	0.62
Douglas fir.........	0.42	0.45	0.47	0.39	0.41	0.41	0.43	0.47	0.48
Western pine.......	0.53	0.51	0.50	0.56	0.48	0.49	0.48	0.58	0.51
Cedar	0.46	0.50	0.50	0.46	0.50	0.50	0.46	0.46	0.48
Chestnut	0.44	0.50	0.48	0.44	0.49	0.47	0.45	0.52	0.48
Cypress	0.41	0.44	0.46	0.41	0.43	0.45	0.47	0.52	0.51
Tamarack	0.41	0.50	0.50	0.41	0.51	0.50	0.40	0.41	0.40
Hemlock	0.33	0.38	0.34	0.33	0.38	0.34	0.34	0.36	0.44
Redwood	0.55	0.50	0.57	0.53	0.48	0.57	0.64	0.63	0.55
White pine.........	0.42	0.47	0.38	0.37	0.46	0.37	0.44	0.51	0.40
Lodgepole pine.....	0.46	0.48	0.50	0.46	0.48	0.50	0.39	0.41	....,
Gum	0.52	0.45	0.23	0.55	0.45	0.23	0.34	.....	.....
Spruce	0.48	0.45	0.39	0.51	0.50	0.46	0.44	0.40	0.38
Beech	0.36	0.44	0.40	0.35	0.44	0.34	0.36	0.42	0.41
All other	0.45	0.38	0.46	0.45	0.37	0.45	0.41	0.43	0.70

PURCHASED BY ELECTRIC RAILROADS.

Total	$0.50	$0.51	$0.56	$0.49	$0.50	$0.56	$0.53	$0.54	$0.58
Oak	0.54	0.53	0.60	0.52	0.52	0.59	0.58	0.56	0.62
Southern pine......	0.61	0.63	0.65	0.50	0.54	0.60	0.69	0.73	0.71
Douglas fir.........	0.35	0.37	0.48	0.39	0.34	0.49	0.35	0.38	0.47
Western pine......	0.53	0.40	0.56	0.82	0.47	0.57	0.37	0.37	0.55
Cedar	0.42	0.44	0.48	0.42	0.45	0.47	0.39	0.42	0.50
Chestnut	0.46	0.47	0.49	0.46	0.47	0.50	0.44	0.48	0.49
Cypress	0.41	0.42	0.47	0.40	0.41	0.47	0.48	0.54	0.58
Tamarack	0.39	0.37	0.43	0.34	0.37	0.41	0.45	.....	0.43
Hemlock	0.31	0.38	0.42	0.31	0.38	0.42	.....	.....	.....
Redwood	0.48	0.52	0.63	0.49	0.51	0.63	0.39	0.58	0.62
White pine.........	0.49	0.60	0.64	0.50	0.63	0.50	0.49	0.43	0.65
Lodgepole pine......	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gum	.....	.....	.....	.....	.....	.....	.....	.....	.....
Spruce	0.54	0.58	.....	0.54	0.58	.....	.....	.....	.....
Beech	0.40	.....	.....	0.40	.....	.....	.....	.....	.....
All other............	0.54	0.49	0.60	0.57	0.51	0.59	0.45	0.45	0.62

In 1909 the average cost per tie was 49 cents as compared with 50 cents in 1908 and 51 cents in 1907. Nevertheless the average cost of all ties reported as purchased was higher in 1909 than in 1906, when it was 47 cents. A comparison of the figures for 1909, 1908 and 1907 shows that in the case of each of the leading kinds of tie timbers, except Western pine, the average price was less in 1909 than in 1907, though the prices paid for chestnut, tamarack and hemlock were greater in 1908 than in 1907. Western pine ties showed an average cost of 53 cents in 1909 as compared with 51 cents in 1908 and 50 cents in 1907. Sawed ties of this timber were purchased for less in 1909 than in 1908 or 1907; but there was a remarkable increase in the cost of the hewed ties, due probably to the inclusion in the reports of large numbers of ties which had been treated with a preservative before purchase.

Hemlock ties fell in price from an average of 38 cents in 1908 to 33 cents in 1909. The average cost of chestnut ties was 4 cents lower in 1909 than in 1907, while that of redwood ties was 6 cents lower.

In 1909 the steam roads and electric roads each paid the same average price for hewed ties. Sawed ties were purchased for the same average price (49 cents) as hewed ties by the steam roads, but the electric roads paid 4 cents more for sawed ties. It is an interesting fact that although the average tie used by the electric roads is smaller than that used by the steam roads, the price paid for it is generally greater. This is due not only to the disadvantages incident to contracts for smaller quantities of material, but also to the fact that the electric roads are more likely to purchase ties at points where the price includes railroad transportation charges.

The highest average price reported by the steam railroads was 64 cents for sawed redwood ties and the lowest 33 cents for hewed hemlock. The electric roads paid as high as 82 cents for hewed Western pine ties, these being practically all treated, while the lowest average price paid by them was 31 cents for hewed hemlock.

PRESERVATION.

Many species of timber unfitted for use as ties because they lack decay-resisting qualities or immunity to insect attacks are made available for the purpose by the use of a preservative treatment. Even in the case of wood that is naturally more or less durable, such treatment is often economical, the added life in service more than paying for the increase in the original cost. Of the 78 species of timber which the different specifications of the steam railroads of the United States permit to be used as cross-ties, over one-half are acceptable for such use only after the application of a preservative. Among the woods most commonly treated are pine, red or black oak, Douglas fir, hemlock, gum, spruce and beech.

The remarkable increase in the use of Western pine, gum, spruce and beech cross-ties, apparent in the reported purchases of ties in 1909, is doubtless due to the use of wood preservatives.

Table 4 shows the number of cross-ties reported as purchased already treated or as treated after purchase by steam and electric railroads of the United States in 1909, 1908 and 1907.

TABLE 4.—NUMBER OF CROSS-TIES PURCHASED ALREADY TREATED OR TREATED AFTER PURCHASE, BY CLASS OF RAILROAD PURCHASING: 1909, 1908 AND 1907.

Class of Railroad Purchasing.	Total Treated.	Treated Before Purchase.	Treated After Purchase.
1909			
All railroads	22,033,000	7,663,000	14,370,000
Steam railroads	21,198,000	7,081,000	14,117,000
Electric railroads	835,000	582,000	253,000
1908			
All railroads	23,776,000	10,973,000	12,803,000
Steam railroads	23,157,000	10,566,000	12,591,000
Electric railroads	619,000	407,000	212,000
1907			
All railroads	19,856,000	8,389,000	11,467,000
Steam railroads	19,192,000	7,975,000	11,217,000
Electric railroads	664,000	414,000	250,000

Of the cross-ties purchased in 1909, 22,033,000 were given a preservative treatment. This number is 1,743,000 less than that reported for the preceding year, but 2,177,000 greater than that for 1907. The proportion which treated ties formed of the entire number purchased was 17.8 per cent. in 1909, 21.1 per cent. in 1908, and 12.9 per cent. in 1907. Of the number treated in 1909, about one-third were treated before purchase and two-thirds after purchase.

The steam railroads treated more ties after purchase in 1909 than in 1908 or 1907, although the total number of treated ties reported by them was 1,959,000 less in 1909 than in 1908. The number purchased by them already treated was 3,485,000 less than in 1908. The electric railroads reported 835,000 treated ties, of which 582,000, or 69.7 per cent., were treated before purchase and 253,000, or 30.3 per cent. after purchase.

There are now more than seventy wood-preserving plants in the United States. A number of the large steam roads possess expensive plants fitted to handle large quantities of timber in a very efficient manner. Nearly all treated cross-ties used by steam railroads are treated in closed cylinders permitting the application of pressure and designed to secure a heavy absorption of the preservative. The principal preservatives used were creosote oil, and, to an almost equal degree, a solution of zinc chloride. Many ties are treated with an emulsion of creosote oil and a solution of zinc chloride, and one road treated large quantities of its ties with a heavy injection of crude petroleum. Other preservatives are also used.

The electric railroads own but a few cylinder-treating plants and are generally obliged to purchase treated ties or to use some less expensive method of treatment, such as dipping the ties in a bath of the preservative. Many different preservatives are used in this manner.

PRESERVATIVES USED.

(Authority, Forest Service.)

Fifty-one million five hundred thousand gallons of creosote and 16,250,000 lbs. of zinc chloride were used in preserving timber in the United States in 1909. Small quantities of crude oil, corrosive sublimate, coal tar and water-gas tar were also used. These figures are based upon reports to the United States Forest Service of forty-six firms operating sixty-four timber-treating plants, which represents 93 per cent. of the plants in operation during that year. These figures show a smaller consumption than in 1908, when forty-four firms operating sixty-four treating plants reported a use of 56,000,000 gallons of creosote and 19,000,000 lbs. of zinc chloride.

Assuming that on an average one gallon of creosote, or one-half pound of zinc chloride, will protect a cubic foot of timber from decay, more than 80,000,000 cu. ft. of cross-ties, piling, poles, paving blocks, mine and other timbers were given a treatment that will greatly increase their life and usefulness.

Since timber treating began on a commercial scale in the United States the domestic supply of creosote has never been equal to the needs of the industry. With the development of wood preservation in recent years the insufficiency of the home production of creosote has become more marked. In 1908, 69 per cent. of the creosote used by the treating plants was imported, and but 31 per cent. was obtained from domestic sources. In 1909, 73 per cent. of the creosote used was imported, and but 27 per cent. obtained in this country. Nearly three-fourths of the imported creosote came from England and Germany; some was obtained from other European countries, and some from Nova Scotia. The domestic creosote was obtained chiefly in New York, Philadelphia and other large cities.

Were all the tar produced which the coal annually coked in the United States is capable of yielding, it would distill considerably more than is now used by the wood preservers and obtained from domestic sources. Unfortunately, American operators do not even get the fullest use of the limited quantity of coal tar made in this country, for it does not pay the operators to distill coal tar for creosote alone; so, unless they can find a market for the associated products, it is not separated. Germany has gone far ahead of the United States in the development of coal-tar products, and her exports of them to this country are steadily increasing.

The zinc chloride used in wood preservation was all obtained from domestic sources, according to the reports, most of it being produced by a few large chemical companies.

Cross-ties are particularly liable to decay, since they are used under conditions which are favorable to the growth of the wood-destroying fungi. Consequently, the railroads have always taken a leading part in timber preservation in the United States. Thirteen railroads report the operation of timber-treating plants; many also have ties and other materials treated by commercial plants.

Reports from sixty-four treating plants show that 16,805,501 hewed ties and 6,010,000 sawed ties were treated by them during 1909. There were also treated by these plants 9,105,627 board ft. of switch ties; 902,793 board ft. of bridge ties; 6,550,619 linear ft. of piling; 1,159,357 sq. yds. of paving blocks, 88 per cent. of which was yellow pine, the remainder being made up of Douglas fir, red gum, etc.; 1,314,172 linear ft. of poles; 67,384 cross arms; 38,838,393 board ft. of bridge timbers, and 16,635,172 board ft. of other construction timbers. Approximately, 4,000,000 board feet of various other materials, such as flooring, mine timbers, wood conduit, car sills, car flooring, etc., were also treated.

The following four companies operating six plants failed to furnish information for this report, and in considering the figures given, therefore, this fact should be taken into account:

Republic Creosoting Company.
Norfolk Creosoting Company.
Eppinger & Russell Company.
Georgia Creosoting Company.

COMPARATIVE STATEMENT OF CROSS-TIES TREATED IN THE UNITED STATES DURING THE YEARS 1907, 1908 AND 1909

Authority for figures, 1907, 1908, Wood Preservers' Association
Authority for figures, 1909, U. S. Forest Service

	1907		1908			1909		
	Number	Equiv. cu. ft.	Number	Equiv. cu. ft.	Per Cent. Incr. 1908 over 1907	Number	Equiv. cu. ft.	Per Cent. Incr. 1909 over 1908
Creosote......	5,750,874	17,252,622	9,620,420	28,861,260	67.29	9,943,360	29,830,080	3.36
Zinc Creosote	2,345,670	7,037,010	3,260,530	9,781,590	39.00	2,698,598	8,095,794	*20.82
Zinc Chloride	9,864,765	29,594,295	8,640,230	25,920,690	*12.42	8,051,054	24,153,162	*7.32

*Decrease.
Note:—Reducing factor, 1 tie=3 cu. ft.

THE SUMMARY OF POLES PURCHASED BY TELEGRAPH AND TELEPHONE COMPANIES, STEAM AND ELECTRIC RAILROADS, ELECTRIC LIGHT AND POWER COMPANIES

(Authority Bureau of Census.)

Kinds of Wood	1909		1908		1907	
	Number	Cost	Number	Cost	Number	Cost
Total	3,739,000	$7,074,000	3,249,000	$5,929,000	3,283,000	$8,082,000
Cedar	2,440,000	4,680,000	2,200,000	3,781,000	2,109,000	5,203,000
Chestnut	608,000	1,383,000	516,000	1,227,000	630,000	1,620,000
Oak	237,000	137,000	161,000	95,000	76,000	60,000
Pine	180,000	520,000	117,000	383,000	156,000	460,000
Cypress	78,000	117,000	91,000	148,000	100,000	308,000
Juniper	44,000	79,000	42,000	83,000	39,000	109,000
Tamarack	30,000	18,000	24,000	32,000	14,000	10,000
Douglas fir	25,000	35,000	20,000	80,000	16,000	41,000
Redwood	23,000	49,000	13,000	39,000	31,000	109,000
Bois d'Arc	21,000	9,000	18,000	11,000	6,000	3,000
Spruce	11,000	18,000	8,000	23,000	11,000	29,000
Locust	10,000	9,000	10,000	8,000	5,000	4,000
All other	32,000	19,000	29,000	18,000	89,000	126,000

Telephone and telegraph companies reported purchases during 1909 of 2,916,000 poles, or 78 per cent. of the total. This was an increase over 1908 in the number reported as bought by this class of users of 354,000 poles, or 14 per cent., and over 1907 of 604,000 poles, or 26 per cent. Steam railroads reported the purchase of 26 per cent. more poles in 1909 than in 1908, though 34 per cent. less than in 1907, while the reported purchases by electric railroads and electric light and power companies were 18 per cent. greater than in 1908, and 7 per cent. less than in 1907.

There was little change in the average cost per pole of all lengths and from all species of wood in 1909, as compared with 1908, it being $1.89 in the later and $1.82 in the earlier year. The average cost per pole, $2.46, in 1907, was substantially larger than in either of the later years, mainly for the reason that a class of pole consumers in the United States which uses chiefly short poles was not included in the census for 1907.

Cedar continues to be the principal pole timber, contributing 65 per cent. of the total purchases in 1909, 68 per cent. in 1908, and 64 per cent. in 1907. Chestnut, after cedar, was used in greatest quantity in all three years, forming 16 per cent. of the total in 1909, 16 per cent. in 1908, and 19 per cent. in 1907. Among the remaining species, the increase in the number of oak poles reported as purchased during the last three years is noteworthy; more than three times as many poles from this species having been reported as purchased during 1909 as was the case in 1907.

Substantial progress in the practice of treating poles with chemicals to preserve them from decay is disclosed by the returns for 1909, nearly one-sixth of the total purchases during that year having been given some preservative treatment, as against about one-tenth in 1908 and one-eighth in 1907.

LIST OF WOOD PRESERVING PLANTS IN THE UNITED STATES—JUNE 1, 1909-JANUARY 1, 1911.

EASTERN STATES.

Authority—Forest Service.

Reference No.	Location.	Managing Company.	Process.
1	Portsmouth, N. H.....	Otis Allen & Son..........	Mercuric Chloride (Kyanizing).
2	Lowell, Mass..........	Otis Allen & Son..........	Mercuric Chloride (Kyanizing).
3	Long Island City, N. Y.	Eppinger & Russell Co.....	Creosote (Bethell).
4	Newark, N. J..........	American Creosoting Co...	Creosote.
5	Maurer, N. J..........	The Barber Asphalt Paving Co..................	Creosote (Bethell and Rueping).
6	New Philadelphia, Pa..	Philadelphia & Reading Coal and Iron Co.	Creosote and Zinc Chloride. (non-pressure).
7	Nanticoke, Pa.........	Delaware, Lackawanna & Western R. R. Co. Coal Mining Dept...........	Creosote (non-pressure).
8	Philadelphia. Pa.......	Pennsylvania R. R. Co....	Creosote (non-pressure).
9	Mt. Union, Pa.........	Pennsylvania R. R. Co....	Creosote.
10	Buell (near Norfolk), Va.	Norfolk Creosoting Co.....	Creosote (Bethell).
11	Buell (near Norfolk), Va.	U. S. Wood Preserving Co	Creosote (Bethell). Creo-Resin.
12	Norfolk, Va...........	Atlantic Creosoting & Wood Preserving Works.......	Creosote (Bethell).
13	Portsmouth, Va.......	The Wyckoff Pipe & Creosoting Co...........	Creosote (Bethell).
d14	Bound Brook, N. J.....	Federal Creosoting Co......	Creosote (Lowry).
d15	Paterson, N. J..........	Federal Creosoting Co......	Creosote (Lowry).

SOUTHERN STATES.

16	Ficklin, Ga............	Georgia Creosoting Co.....	Creosote.
17	Atlanta, Ga...........	So. Wood Preserving Co..	Creosote.
a18	Mobile, Ala...........	Republic Creosoting Co....	Creosote.
19	Gulfport, Miss.........	Gulfport Creosoting Co....	Creosote (Bethell and Rueping).
20	Gautier, Miss..........	West Pascagoula Creosote Works.................	Creosote (Bethell).
b21	Grenada, Miss.........	Ayer & Lord Tie Co.......	Creosote (Bethell and Rueping). Zinc Chloride (Burnettizing).
22	New Orleans, La.......	American Creosote Works, Inc....................	Creosote.
23	New Orleans, La.......	New Orleans Wood Preserving Co.............	Creosote.
24	Slidell, La.............	Southern Creosoting Co., Ltd...............	Creosote (Bethell).
d25	Shreveport, La........	Shreveport Creosoting Co., Ltd....................	Creosote. Zinc-Creosote (Allardyce).
26	Winfield, La..........	Louisiana Creosote Co.....	Creosote (low pressure).
27	Texarkana, Tex.......	National Lumber & Creosoting Co..............	Creosote (Bethell). Zinc Chloride (Burnettizing).
28	Texarkana, Tex.......	International Creosoting and Construction Co...	Creosote (Bethell). Zinc Chloride (Burnettizing). Zinc-Creosote (Allardyce).
29	Beaumont, Tex........		
30	Houston, Tex.........	Texas & New Orleans R.R.	Creosote (Bethell). Zinc Chloride (Burnettizing).
31	Galveston, Tex........	Galveston Creosoting Co...	Creosote (Bethell).
32	Somerville, Tex........	Texas Tie & Lumber Preserving Co.	Creosote (Bethell and Rueping).
33	Greenville, Tex........	Missouri, Kansas & Texas Railway...............	Creosote (Rueping).
b34	Argenta, Ark..........	Ayer & Lord Tie Co.......	Creosote (Bethell and Rueping). Zinc Chloride (Burnettizing.)
d35	Hugo, Okla...........	American Creosoting Co...	Creosote (Lowry).
36	Jacksonville, Fla......	Eppinger & Russell........	Creosote.
37	Birmingham, Ala......	Tennessee Coal & Iron Co..	

CENTRAL STATES.

Reference No.	Location.	Managing Company.	Process.
a38	Indianapolis, Ind.	Republic Creosoting Co.	Creosote.
d39	Shirley, Ind.	American Creosoting Co.	Creosote.
40	Columbus, Ind.	Indianapolis, Columbus & Southern Traction Co.	Creosote (low pressure.) Zinc Chloride.
41	Terre Haute, Ind.	Indiana Zinc Creosote Co.	Zinc Chloride (Burnettizing). Zinc-Tannin (Wellhouse).
42	Evansville, Ind.	The Indiana Tie Co.	Zinc Chloride (Burnettizing).
d43	Bloomington, Ind.	American Creosoting Co.	Creosote (Lowry).
44	Escanaba, Mich.	Chicago & North-Western R. R. Co.	Zinc-Creosote (Card).
d45	Marion, Ill.	American Creosoting Co.	Creosote (Lowry).
b46	Carbondale, Ill.	Ayer & Lord Tie Co.	Creosote (Bethell and Rueping). Zinc Chloride (Burnettizing).
c47	Paris, Ill.	Chicago Tie Preserving Co.	Zinc-Creosote.
c48	Mt. Vernon, Ill.	Chicago Tie Preserving Co.	Zinc-Tannin (Wellhouse).
49	Waukegan, Ill.	Chicago Tie & Timber Preserving Co.	Zinc-Creosote (Card).
f50	Galesburg, Ill.	Chicago, Burlington & Quincy R. R.	Zinc-Creosote (Card).
51	Joppa, Ill.	The Indiana Tie Co.	Zinc Chloride (Burnettizing)
52	Madison, Ill.	Kettle River Co.	Card-Buehler).
53	Sandstone, Minn.		
g54	Brainerd, Minn.	Northern Pacific Ry. Co.	Creosote (Lowry).
a55	Minneapolis, Minn.	Republic Creosoting Co.	Creosote.
d56	Kansas City, Mo.	American Creosoting Co.	Creosote (Lowry).
d57	Springfield, Mo.		
58	Kansas City, Kan.	Kansas City Creosoting Co.	Zinc Chloride (Burnettizing). Creosote (Rueping and Bethell). Zinc-Creosote (Rütger). Zinc-Tannin (Wellhouse).
h59	Topeka, Kan.	Union Pacific R. R. Co.	Zinc Chloride (Burnettizing).
d60	Toledo, Ohio	Federal Creosoting Co.	Creosote (Lowry).

ROCKY MOUNTAIN AND PACIFIC STATES.

Reference No.	Location.	Managing Company.	Process.
61	Lead, S. Dak.	Homestake Mining Co.	Creosote (non-pressure.)
g62	Paradise, Mont.	Northern Pacific Ry. Co.	Creosote (Lowry).
63	Somers, Mont.	Great Northern Ry. Co.	Zinc Chloride (Burnettizing).
f64	Sheridan, Wyo.	Chicago, Burlington & Quincy R. R.	Zinc Chloride (Burnettizing).
h65	Laramie, Wyo.	Union Pacific R. R. Co.	Zinc Chloride (Burnettizing).
66	Alamogordo, N. Mex.	Alamogordo Lumber Co.	Wellhouse.
67	Albuquerque, N. Mex.	Atchison, Topeka & Santa Fe Ry.	Creosote. Crude Oil.
68	Burke, Idaho	Hercules Mining Co.	Creosote (low pressure).
69	Kellogg, Idaho	Bunker Hill and Sullivan Mining & Concentrating Co.	Creosote (low pressure).
70	Seattle, Wash.	Colman Creosoting Works.	Creosote (Bethell).
71	Eagle Harbor, Wash.	Pacific Creosoting Co.	Creosote (boiling).
72	Lowell, Wash.	Puget Sound Wood Preserving Co.	Creosote (special).
73	Wyeth, Ore.	O. R. & N. Co.	Creosote (boiling). Zinc Chloride (Burnettizing).
74	West Oakland, Cal.	Southern Pacific Co.	Creosote (boiling). Zinc Chloride (Burnettizing).
75	Los Angeles, Cal.		
76	Near East San Pedro, Cal.	San Pedro, Los Angeles & Salt Lake R. R. Co.	Creosote. Zinc Chloride (Burnettizing).
77	Butte, Mont.	Anaconda Copper Mining Co.	
78	Albuquerque, N. Mex.	Texas Tie and Lumber Preserving Co.	

a—Republic Creosoting Company, see numbers 18, 38, 55.
b—Ayer & Lord Tie Company, see numbers 21, 34, 46.
c—Chicago Tie Preserving Company, see numbers 47, 48
d—American Creosoting Co., see numbers 14, 15, 25. 35, 39, 43, 45, 56 57, 60
e—Indiana Tie Company, see numbers 42, 51.
f—C. B. & Q. R. R., see numbers 50, 64.
g—Nor. Pac. Ry. Company, see numbers 54, 62.
h—Union Pacific R. R. Company, see numbers 59, 65.

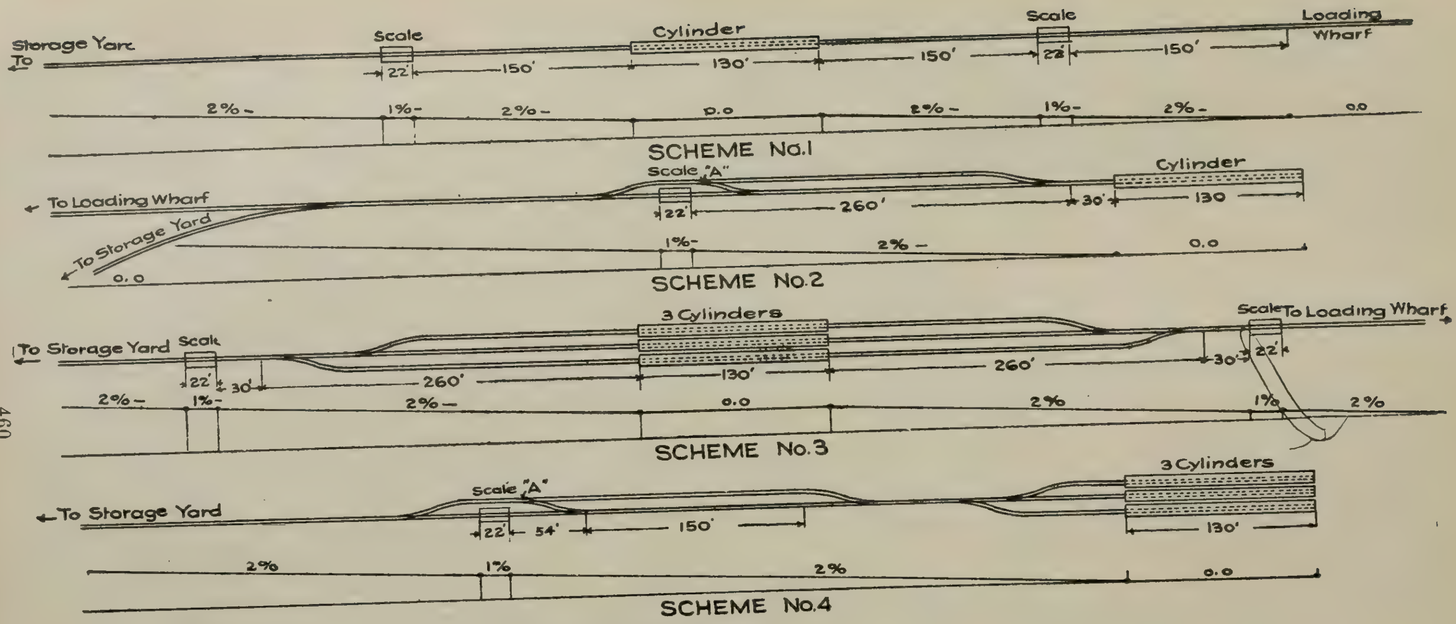
Appendix F.

REPORT OF SUB-COMMITTEE ON NECESSITY FOR THE USE OF TRACK SCALES IN TIMBER TREATING AND RESULTS TO BE OBTAINED FROM THEIR USE.

In the treatment of timber it is of the greatest importance that accurate means be used for determining the exact quantities of preservatives put into the timber and left in the timber. In most treating plants, both in this country and abroad, the actual quantities of preservatives injected into the wood are measured by volumetric determination, that is, the amount of liquid injected is determined by measuring the quantity of liquid in the storage tank before the treatment and again after treatment, the differences (measured in gallons) being taken as the quantity injected into the wood. The volumetric method, with care and attention, can be made to record the quantities of liquid absorbed with great accuracy, and in many of the modern treating plants the degree of accuracy obtained in making volumetric determinations has been excellent. There are certain factors of error in making volumetric determinations, however, which it is almost impossible to avoid. In order to assist in correcting these errors and to check the volumetric readings, many treating plants have installed small track scales as a part of the equipment of the plant. These scales are generally used to check the volumetric determinations, that is, the timber is weighed on these scales before treatment and immediately after treatment. It should be pointed out, however, that even with the most careful work, the determination by weight of the liquid absorbed is not absolute. The degree of seasoning must be taken into consideration, except where thoroughly seasoned timber is treated, and the amount of moisture that may be in the timber, caused by a heavy rain, or the amount of snow and ice which accumulates on it, as well as the tram cars in the winter time may be a source of considerable error. Some of the preservatives injected will usually run out of the timber during the period between the end of the treating operation and the end of the weighing operation, or in the case of creosote oil a certain percentage of the oil will evaporate from the hot timber before the end of the weighing operation is reached. The tram cars should be light-weighed and stencilled, and should be re-weighed as frequently as necessary to check the tare weights.

The value of the track scale, however, in connection with the operations of the timber treating plants, lies in the fact that the determinations of the liquid absorbed by weight act as a very efficient check on the determinations by volume. With careful work the determinations by weight and volume should check reasonably close.

From the answers which your Sub-Committee has received, it appears that most of the railroad companies in this country use the track



Note:- Recommended profile to facilitate weighing Trams to be weighed on descending grade.—

If local conditions do not permit such grades they will have to be changed to suit.—

Crossovers marked "A" near scale are there to prevent unnecessary use of scale

SKETCHES
SHOWING LOCATION OF SCALES
AND ARRANGEMENT OF TRACK
IN CONNECTION WITH TIE CREOSOTING PLANTS

scale occasionally to check the volumetric readings, and in one case every tram of timber or ties treated is weighed before and after treatment. It would be extremely desirable that determinations of the preservative absorbed be made for every run that is made. There are so many variables in the treatment of timber due to the nature of the material and to the varying conditions of seasoning, the kind of wood, etc., that any method which would increase the regularity of the treatment should be adopted.

Attached hereto is a report from one of the treating plants on the Rock Island, showing the quantity of oil absorbed per tie for every run for a period of two weeks, one line showing the quantity as determined by volumetric readings and the other line showing the quantity as determined by track scale weighing. It will be noted that in this particular test the variation was very small. In view of the fact that past experience has shown that there are always some differences in the readings by weight and volume, your Committee has endeavored to ascertain how great the variations may be and still indicate fairly accurate determinations. According to the reports of some of the European railroads, a variation of 15 per cent. between volumetric readings and weights is allowable. In this country the variation hardly ever reaches such a high figure; in the majority of instances they will not be more than 10 per cent., and usually very much less than that.

If correctly designed scales are properly installed and maintained and a reasonable amount of care exercised in weighing, making allowance for conditions which may affect results as obtained by weighing and volumetric determinations, there should be even smaller variations between the two methods.

The design and size of scales to be installed will depend, to a great extent, on local conditions and the sizes of timber to be treated.

Having in mind a scale for general use, such as the weighing of ties and timber up to 35 or 40 ft. in length, it is the recommendation of your Sub-Committee that a 22-ft, 2-section, 50,000 lbs. capacity, suspension bearing platform scale be installed directly on cast-iron plates embedded in concrete, with the pit of sufficient size to permit thorough inspection and cleaning.

The platform bearings should be of sufficiently rigid I-beams and on top of these should be placed the ties carrying the scale rail stands. The deck should be rigid and not connected with the scale, but shields applied to the rails to keep as much dirt and water out of the pit as possible. The scale should be fitted with a capacity beam, graduated and sensitive to 2½ pounds in 50,000 pounds.

This type scale is recommended for the reason that it is so designed as to be accessible in all of its parts for thorough cleaning and inspection, owing to the desirability of the suspension feature over scales where the shock is transmitted to the bearing points with a direct thrust. It should be purchased and installed for approximately $1,200.00.

A two-section scale is recommended on account of its greater accuracy over one containing more sections, and 22 ft. is about as long as it is desirable to install a two-section scale.

While various lengths of tram cars are used by various railroads in timber treating plants, it would seem that one about 7½ ft. long, with 5-ft. wheel base, would be the most desirable, inasmuch as the bottom ties will then project over the end of the car, providing a hand-hold at each end when unloading. Such a scale as recommended above will permit weighing of two trams at a time, if necessary or desirable.

In case ties alone are to be weighed in single tram loads, a scale 10 to 12 ft. in length and of ten tons capacity, of the "A" lever type, similar to those ordinarily used in warehouses and for wagon scales, may be used. The cost of this scale will be approximately $350, installed with concrete and timber.

For more enduring accuracy and service, it is recommended that a 10 to 12 ft. 15-ton scale of the suspension bearing type, similar to the 22-ft. 2-section scale, already described, be installed with concrete and steel at an approximate cost of $700.00.

Attached hereto is a sketch showing the proposed location of scale and arrangement of tracks, where one or more cylinders are used, and where trams are shoved into one end of the cylinder and pulled out of the other, or where shoved into and pulled out of the same end. Such an arrangement permits trams to be weighed ready to be placed into the cylinder as soon as it is emptied, without delaying the output of the plant. If the profiles shown can be adopted the trams may be handled to advantage by men instead of engine, when weighing.

The tracks, switches and cross-over are so arranged as to permit weighing at all times on descending grade. If local conditions do not permit of the arrangement as shown on sketch, with the advantages outlined above, the arrangement will have to be modified to suit the conditions.

Attached is a statement showing information in regard to scales located at various timber-treating plants. It would seem from most of the replies that a depot scale has been installed, and while satisfactory for freight house and other light work, is not desirable for track scale weighing, in that it is not durable and the arrangement of the levers is such that the friction is across the knife edges instead of in the direction of its length. It is also impossible to clean and inspect it with the same thoroughness as the scale recommended.

One of the members of the Committee recently visited a large number of the European timber-treating plants and made special inquiries as to the prevailing practice concerning the use of track scales in connection with the treatment of ties and other railroad timbers. It was found that almost all of the timber-treating plants on European railroads are equipped with track scales, and at most of these treating plants all ties and other timbers are weighed on trams before being treated and again after treatment. This method of checking the oil absorption

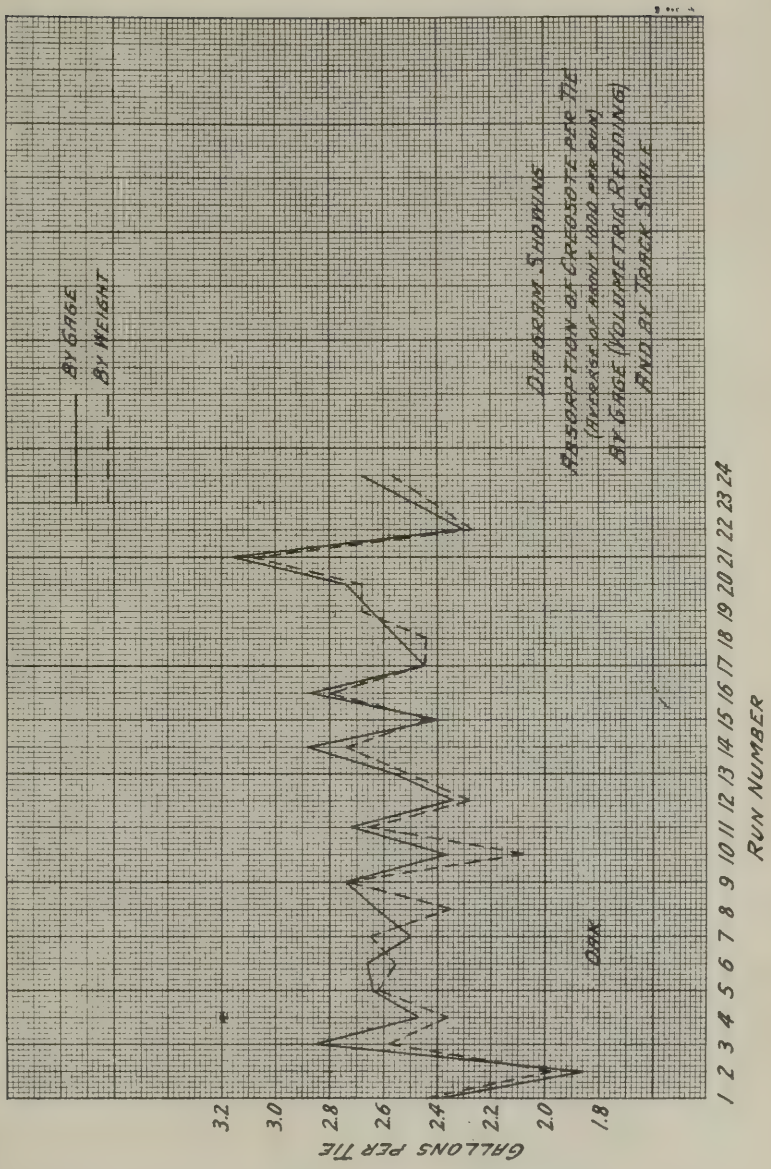


Diagram Showing
Absorption of Creosote per Tie
(Average of about 1000 per run)
By Gage (Volumetric Reading)
And by Track Scale
By Gage
By Weight
Oak
Gallons per Tie
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
Run Number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

STATEMENT SHOWING INFORMATION IN REGARD TO SCALES LOCATED AT TIMBER TREATING PLANTS.

Road or Company	Location of Plant	Length of Scale	Width of Scale	Capacity	Beam Graduation	Cost	Remarks
Illinois Central...............	Memphis, Tenn........	5 ft.	5 ft.	9000 lbs.	2 lbs.	$ 74.00	Not including installation, scale an old one.
D. L. & W....................	Paterson, N. J.........	8 ft.	4 ft.	15 tons	2½ lbs.	403.83	$223.83 of this for installation.
Lehigh Valley................	Bound Brook, N. J....	7 ft. 10¾ in.	4 ft. 10½ in.	31,000	5 lbs.	275.00	$100 of this for installation.
C. B. & Q....................	Galesburg, Ill.........	20 ft.	4 ft.	40,000	20 lbs.	....	
Frisco........................	Hugo, Oklahoma and Springfield, Mo......	7 ft. 9¾ in.	4 ft. 10 in.	....	....	600.00	$246 of this for track charges.
Rock Island..................	Tie Plant, Ark., and Kansas City, Mo....	8 ft. 3 in. 7 ft. 11 in.	5 ft. 3 ft. 11¼ in.	....	20 lbs. 20 lbs.	504.36 473.64	$364.36 of this for installation. $333.64 of this for installation.
West Pascagoula Creo. Co.....	Gautier, Miss..........	None	....	....	....	....	Recommend scales.
Texas and Lumber Pres. Co....	Somerville, Texas.....	8 ft. 38 ft.	....	8,000 120,000	.... 10 lbs.	.... 480.00	Not clear whether this is cost of scales alone or includes installation; should think just the scales.
M. K. & T....................	Dennison, Tex.........	None	....	....	....	....	Recommend 40 ft. scale, 6 to capacity.
N. P.........................	Brainard, Minn........		Small scales to weigh a tie				Recommend track scales.

is possible because of the small daily output of treated material. Most of the cylinders hold only from three to four trams of ties. These trams are pushed onto the scale by hand before treatment and again after treatment. The weighing operation takes about five to ten minutes for each tram, because in the majority of instances the scale is situated at the end of a spur track and the tram has to be pushed onto it, weighed and pushed off again before the next tram can be weighed.

The type of scale used differs materially from that hitherto used in the United States. Practically all of the scales are the so-called printing scales, that is, the operator pushes a number of levers on the scale arm until the scale balances, a card is then pushed into the slot, and, by pressing on a small lever, the exact weight is printed on the card. Errors of observation are thereby made practically impossible. There are frequently several thin sheets of paper pasted to the cards which are used so that duplicate and triplicate slips are made at one pressure of the lever, one slip remaining with the treating company and the others with the railroad officer in charge. These scales weigh with great accuracy, weights being obtained down to one (1) kilo, which is equal to 2.2 lbs.

A visit was made to a large scale factory, where a type of scale is now being made which weighs cars and records the weights automatically, that is, the cars are run over the scale slowly, and each car stops on the scale platform only long enough for the weight to be registered. This registering is made on a small card, which drops into a small box at the side of the scale box. These automatic scales are now being made in this country, and are worthy of serious consideration.

The general impression obtained, after visiting many of the European timber-treating plants, is that the timber-treating engineers are fully convinced that the weighing of timber before and after treatment is very desirable and of great assistance in regulating the treatment. They stated that the weighing of every charge is very desirable but not essential, and where the weighing of every charge was carried out, it was explained that this was done, owing to the fact that the time required was insignificant at a plant treating only a small quantity of material daily. This should be kept in mind in considering the adoption of a similar method in this country.

Another point of great importance in connection with the weighing of timber before and after treatment is the variation observed between volumetric readings and weight readings of the preservative actually injected. Without going into details, it may be stated that the variations observed between weight and volumetric readings in the European treating plants was very much greater than those which have been obtained in the United States. At one plant, the variation in 16 runs showed the average absorption as indicated by weight to be 6 to 7 per cent. below the average volumetric readings (the minimum being 2 per cent. and the maximum 16 per cent.), and in four cases the absorption by weight was greater than the volumetric reading, the minimum being 1 per cent.

and the maximum 20 per cent. The government officials at this plant indicated that these were usual conditions.

It is particularly gratifying to the Committee to report that the American operative methods have shown a very much closer approximation between the volumetric and weight readings than has been the case in the European plants. It was noted in the accompanying diagram, showing the results of weights taken at one of the American timber-treating plants, that the variation averages 2 to 3 per cent.

The general findings of the Sub-Committee are that track scales are now being used at a small number of treating plants in this country, and quite generally in Europe they are used to check the work of the plant, with excellent results. Your Committee recommends that the track scale be installed at every treating plant wherever possible. After their use has become general, it will be possible to obtain data which will permit one to state more definitely the variation which will take place in treatment, and thus enable one to formulate some general rules as to the extent of allowable variation.

Appendix G.

NOTE ON THE STRENGTH OF TIES TREATED WITH CRUDE OIL.

By W. K. HATT, Purdue University.

In the report of the Committee on Wood Preservation for 1909, Proceedings, Vol. 10, page 615, it was observed that the various treatments had little, if any, effect on the strength of the ties to resist the pressure of the rail, except in the case of those treated with crude oil. In Proceedings, Vol. 11, Part 2, page 827, 1910, the statement was made that this weakening of the ties treated with crude oil was temporary in character, as indicated by later tests.

The facts with reference to this matter are shown in Table 1 below. The values obtained in tests made at various dates are recorded for three kinds of tests.

(1) The rail-bearing test, so called, in which a base of a rail is pressed against the tie, and the yielding of the surface of the tie observed. The load at which a yielding of one-quarter of an inch is recorded. This is beyond the elastic limit of the surface fibers.

(2) The load at which a common spike is pulled longitudinally from the tie.

(3) A novel test, developed from the Brinell test for hardness of metals, determines the load at which a steel ball is pressed half of its diameter in wood. The test for wood was first used by Janka of the Austrian Forest Experiment Station, and has been provided with simple apparatus and investigated by the writer at Purdue University. Obviously such a test, using a $\frac{7}{16}$-in. ball, will detect small differences of strength locally on the surface of wood, and many tests must be averaged to integrate a surface. It is one of the most quickly applied tests, and economical. It requires only a small machine and may be made in the field. Furthermore, the test piece is not destroyed.

Comparisons of the strength of different woods or of the effect of technological processes on wood can be easily made. Considerable investigation has been directed toward the determination of the relation between this ball test and the other strength functions.

The special apparatus is simple: A $\frac{7}{16}$-in. ball; a steel plate $\frac{7}{32}$-in. thick, carefully planed, about 1 in. square, with a hole bored therein slightly in excess of $\frac{7}{16}$-in. diameter. The plate is placed on a planed surface of the wood, the ball placed in the hole, and pressed in the wood by the testing machine. Obviously, when the ball is in the wood one-half of its diameter the plunger of the testing machine will come in contact with the plate; and the scale beam of the testing machine, which has been kept floating, will suddenly rise. The attendant is thus able to observe the load required to press the ball half of its diameter in the wood. A neater and more accurate method is to constantly rotate the plate by hand until the increased resistance to this rotation, caused by the contact of the plunger with the plate, indicates the standard load.

These crude oil ties were treated about April, 1909, first tested August, 1909, and finally December, 1910.

Table 1 shows the change in strength and weight. The indications are:

(1) That the weakness of the surface of the treated loblolly and short-leaf pine, originally evident, has disappeared with whatever changes have gone on in the ties while drying.

(2) That the diminution of spike-holding power had not in April, 1910, been overcome by seasoning. Naturally, the effect of this seasoning would first be evident on the surface and, later on, in the interior to which the spike penetrates.

TABLE 1—TESTS OF TIES TREATED WITH EBANO CRUDE OIL

Species	Rail Bearing (Pounds per square inch)			Ball Test (Pounds)			Spike Pulling (Pounds)			Date
	Natural	Treated	Per Cent	Natural	Treated	Per Cent	Natural	Treated	Per Cent	
Loblolly Pine................	1094	728	66	....	....	....	3894	2069	55	1909, Aug.
	1117	1127	99	766	695	88	2854	1579	55	1910, April
	....	....	....	808	767	96	3335	1286	39	1910, Dec.
Shortleaf Pine................	1035	727	70	....	....	....	4068	1816	45	1909, Aug.
	1302	965	74	757	741	97	3422	1649	48	1910, April
	....	....	....	805	779	96	3070	1477	48	1910, Dec.
Red Gum....................	1104	1047	95	....	....	....	3615	2540	70	1909, Aug.
	1299	1202	93	701	726	....	4217	2850	68	1910, April
	....	....	....	832	823	99	3322	2612	78	1910, Dec.

Notes:—Ties stored indoors after test of 1909.

Spikes used not necessarily same standard at different dates, values comparable horizontally. Five ties averaged for each value. Ten spikes, two per tie, averaged for each value.

Rail Bearing—Crushing under rail at ¼ inch deformation.

Ball Test—Pounds to press 7-16-inch ball in surface 7-32 inch.

Spike Pulling—Pounds to pull out common spike.

Deduction:—For treated ties: Weakness of surface had disappeared December, 1910. See Ball Test and Rail Bearing. Deficiency of spike-holding resistance of treated ties not overcome December, 1910.

Appendix H.

THE ELECTRICAL RESISTANCE OF TIMBER AS AFFECTED BY TREATMENT WITH PRESERVATIVES.

(Abstract of Thesis by J. T. BUTTERFIELD.)

An investigation to determine the resistance of ties as affected by treatment with preservatives was made by Mr. J. T. Butterfield, of the School of Electrical Engineering at Purdue University, in the spring of 1910.

The material available for the tests consisted of four shipments of ties, described in the Fourth Progress Report of Tests on Treated Ties, by W. K. Hatt, found in Proceedings of the American Railway Engineering and Maintenance of Way Association, Vol. II, Part 2, 1910, page 827. The specimens tested vary in size from half a tie to a small section cut from half a tie.

The resistance was measured by the method commonly used for measuring the insulation resistance of electrical machinery, namely, by means of a direct current volt meter of known resistance. This method was applied in two ways. (1) The contact surface for flow of current in the ties was a sawn surface as nearly plane as possible. Contact pressure of 250 lbs. per sq. in. was applied in a Riehle Testing Machine by means of sheet-iron pans, placed one above the other and filled between with dry sand, by which constant surface resistance was obtained. (2) After some of the fundamental laws were investigated, the resistance of the various ties was compared by measuring the current flowing between two spikes driven 20 in. apart in the face of each tie. Then the relation of these latter tests, between the two spikes, to the conditions obtaining in a full tie with rails spiked thereto was investigated.

In beginning the tests the principal elements which cause the resistance to vary were determined and investigated in the following order:

(1) Amount of moisture present.
(2) Kind of wood.
(3) Treatment.
(4) Direction of grain.
(5) Contact pressure.
(6) Temperature.
(7) Amount and time of current flowing.
(8) Dimensions of specimen.

MOISTURE.

The important effect of moisture is plainly shown by the following tables, determined by the testing-machine method:

TEST OF RED OAK.

Zinc Chloride Treatment 1.7 Per Cent.

Per Cent. Moisture.	Ohms Per Cu. In.
14.4	3,370,000
17.	414,000
19.1	94,000
27.4	2,140
35.7	1,381
47.	1,310
52.2	1,100
Untreated.	
13.3	5,020,000
17.3	784,000
21.6	198,000
26.6	136,300
38.0	7,100
43.3	6,440
47.3	5,070

In order to investigate the longitudinal distribution of resistance through a tie, a number were cut up into 6-in. lengths and the resistance measured parallel with the grain. The results plainly showed that there was an enormous resistance at the ends of a tie, which may have a uniformly low resistance in the interior. The cause for this high-end resistance was, of course, the drying out of the ends.

KIND OF WOOD AND TREATMENT.

In measuring the resistance of different woods, the method used was that of determining the resistance between two spikes, as described above. The ties were generally tested in the yard and had been piled. Some were covered and were no doubt less dry than others. Variation in resistance of untreated ties of same species is to be accredited to moisture variation. Generally tests of 5 treated and 15 natural ties enter into the average.

	Resistance. (megohms per half tie.) Natural.	Resistance. (megohms per half tie.) Treated.	Ratio of treated to natural.
Lowry Creosote Process.			
Red oak	.182	.177	.973
Reuping Process.			
Loblolly pine	5.58	5.05	.91
Short-leaf pine	2.97	1.035	.35
Long-leaf pine (very dry)	5.4	6.05	1.12
Red gum	.39	0.22	.58
Loblolly pine	1.46	1.41	0.96

Full Cell Process.

Loblolly pine	2.94	1.00	.34
Short-leaf pine	3.41	2.70	.79
Long-leaf pine	1.80	2.2	1.22
Red gum	.225	.28	1.24
Loblolly pine	4.47	0.905	0.20

Ebano Crude Oil Process.

Loblolly pine	4.47	.666	.15
Short-leaf pine	5.00	2.27	.45
Red gum	.279	.185	.59

Zinc Chloride Process.

Red oak	0.08	0.0125	0.156

DIRECTION OF GRAIN.

The direction of the grain has a decided effect upon the resistance of wood, and as the resistance of ties was taken parallel with the grain, little consideration was given the question aside from the following tests:

Resistance in Megohms.

Kind of wood. 3-in. cubes. Air dried.	Lengthwise.	Radial to growth rings.	Tangential to growth rings	Per cent. Moisture.
Natural red oak	.0175	.12	.15	25
Natural red oak	.0175	.041	.07	40

CONTACT PRESSURE.

The study of the effect of contact pressure on a number of different specimens held between contacts in the testing machine and involving the longitudinal resistance corresponding to different loads developed the following results. As would be expected, it was found that the resistance decreases rapidly with increase of contact pressure.

Red Oak, Zinc Chloride Treatment, 3-in. Cubes.

Lengthwise of Grain. Air dried.

Lbs. per sq. in.	Ohms.
500	175
278	180
56.5	220
22.2	270
8.9	460
3.3	575
1.1	1550
0	5850

Red Gum, No Treatment, 3-in. Cubes.

Lengthwise of Grain. Air dried.

55·5	26400
33·3	26800
22.2	27700
15·5	30350
11.0	32700
7·9	33000
5·5	39400
0	67000

TEMPERATURE.

Some preliminary tests were made upon the ties to discover the effects of temperature. The results, although not capable of representation by a smooth curve, showed that the resistance decreased with an increase of temperature in a nearly direct proportion.

RED OAK.

Zinc Chloride Treatment—Testing Machine Method. End of Grain.

Block = 5 in. x 8 in. x 6 in.

Temperature = Average of Six Thermometers.

Temperature, Degrees C.	Resistance, Ohms.
·33	2500
3·65	2100
5·70	1945
7·50	1820
10.70	1560
12.20	1270
14·50	1050
16.70	910
21.00	670
22.50	623

ELECTROLYTIC EFFECT.

While measuring a low resistance in the testing machine with a high voltage it was noticed that the voltmeter needle tended to fall back rapidly if the circuit was allowed to remain closed for a short time. This pointed to some kind of an electrolytic effect, and some tests were therefore made in which the current was allowed to flow for some time until the resistance became nearly constant. Then the circuit was opened and the specimen allowed to recover. The following are the results:

ELECTROLYTIC EFFECT.

Natural Red Oak. 60 Per Cent. Moisture.

Time.	Volts.	Ohms per cubic in.
0:00 sec.	13.	1010
0:15 sec.	12.80	1130
0:30 sec.	12.70	1190
1:00 min.	12.61	1248
2:00 min.	12.55	1288
3:00 min.	12.50	1320
4:00 min.	12.47	1340
6:00 min.	12.41	1380
	Circuit Opened.	
7:00 min.	12.40	1386
8:00 min.	12.79	1140
9:00 min.	12.86	1101
10:00 min.	12.92	1056
11:00 min.	12.92	1056

INFLUENCE OF VOLUME.

The relation of resistance to the dimensions of the specimen was plainly showed to vary the same as with any conducting material.

Red Oak—Zinc Chloride Treatment.

Length.	Section.	Resistance, Ohms.
6 in.	3 sq. in.	9790
9 in.	3 sq. in.	16030
12 in.	3 sq. in.	22500
15 in.	3 sq. in.	35500

Red Oak—Natural.

Length 3 in. Cross section varied.

Cross section, sq. in.	Resistance, Ohms.
9	6000
18	11000
27	16000
36	22000

RELATION OF TESTS BETWEEN SPIKES TO ACTUAL TIE.

A few tests were made with rails spiked to a whole tie, and the resistance measured and compared to the resistance of spikes 20 in. apart.

The resistance between the rails spiked to the whole tie was found to be about 1.8 times the resistance between spikes driven 20 in. apart and 4½ in. in the face of the tie.

The moisture condition of the surface of the tie was artificially varied.

H = The percentage increase in conductivity between rail and tie, due to rail bearing. For example, the value of H = 0.95 for oak ties is found as follows:

$$H = \frac{\frac{1}{44400} - \frac{1}{44800}}{\frac{1}{44800}} \times 100 = 0.95 \text{ per cent.}$$

CONDUCTIVITY OF TIE WITH RAILS SPIKED THERETO AS COMPARED WITH SPIKES ALONE.

Section of 85-lb. Rail Spiked to Ties at Standard Gage Distance.
No. 6 is Red Oak. No. 7 is Chestnut.

Condition of Tie.		Ohms.	H. Per cent.
Dry; spikes only	No. 6	44800	0.95
	No. 7	9500	2.16
Dry; with rails	No. 6	44400	
	No. 7	9300	
Wet at rail bearing; spikes only	No. 6	43700	0.93
	No. 7	9400	6.79
Wet at rail bearing; with rails	No. 6	43300	
	No. 7	8800	
Wet all over; with rails	No. 6	27800	
	No. 7	7760	
Bottom of tie in wet gravel; with rail	No. 6	10270	
Tie in moist gravel ballast; with rail	No. 7	4350	
Tie in very wet ballast; with rail	No. 6	6780	7.68
	No. 7	3220	6.52
Same as above; spikes only	No. 6	7300	
	No. 7	3430	

The resistance of the bearing between a newly spiked dry rail and a dry red-oak tie will be found to be approximately one per cent. of the total conductivity of the tie, but after the spikes have loosened the pressure on the rail bearing is about the weight of rail per tie divided by the area of the bearing. This is about two pounds per square inch. Such light pressure means high contact resistance. Considering the further fact that the crosswise resistance of a tie is several times its lengthwise resistance per unit of length, and that all leakage current through the rail bearing must pass through a considerable amount of cross-grain resistance, the total resistance of the leakage path between rails is very high.

CONCLUSIONS.

The results obtained tend to establish the following conclusions:

Timber is ordinarily classed with the non-conductors. When dry and well seasoned, it has a very high dielectric strength and practically infinite resistance. When green or moist, however, timber becomes a kind of electrolytic conductor of comparatively low resistance. The treatment with zinc preservatives has the simple effect of producing in the wood a stronger electrolyte and hence a better conductor of current.

(1) The resistance of timber varies directly with the length and inversely with the cross section.

(2) The resistance of timber varies almost inversely with the amount of moisture present, between the limits of 15 and 50 per cent.

(3) The resistance of timber is lowest when measured along the grain, and highest when measured tangentially to the growth rings.

(4) When treated with a soluable salt such as zinc chloride, the resistance varies approximately inversely as the amount of the salt present.

(5) Treatment with such a soluable salt does not change the behavior of the resistance with respect to the per cent. moisture present. Only the amount of the resistance is changed.

(6) The resistance of timber varies almost inversely with the temperature between the limits of zero and 50 degrees Centigrade.

(7) The resistance of non-porous woods, such as the pines, is higher than that of porous woods, such as the oaks and red gum.

(8) Treatment of timber by different creosote processes does not greatly change the natural resistance of the timber.

(9) Finally, all the data taken goes to establish the view that the conductivity of wood is due primarily to the presence in the pores of an electrolyte formed by an aqueous solution of the salts found in the natural timber, or of these salts and others artificially introduced.

Assuming the worst condition for leakage covered by the test, i. e., red oak ties treated with zinc chloride laid in wet ballast and with wet rail bearings, the resistance between the rails of a block one mile in length would approximate 30 ohms. This would permit a leakage current of .05 ampere to flow with the battery voltage of 1.5 volts. The leakage loss would, therefore, be .075 watt, or about 30 per cent. of the power required to operate the relay. This should not seriously interfere with the operation of signals, as leakages up to 60 per cent. exist without such serious interference.

It is to be regretted that determinations of resistance were not made with wet ties or with ties and rails partially immersed in water, as is sometimes the case in practice, for it is believed that under such conditions the leakage current would probably be sufficiently large to interfere with the successful operation of relays.

As a final conclusion, it should be noted that since the above results show only a reduction in resistance of a tie of from 26 to 53 per cent. when treated with zinc chloride, depending upon the percentage of moisture, while a change of resistance by the ratio of 25 to 1 may be effected by varying the kind of wood, a change of 33 to 1 by varying the pressure upon the tie sufficiently, and of 3.7 to 1 by temperature changes, it follows that the treatment of ties with preservatives should not interfere with the operation of signal circuits, except possibly in exceptional cases in which the resistance of the leakage paths is abnormally low from other causes.

DISCUSSION.

(In the absence of the Chairman of the Committee on Wood Preservation, the report was presented by the Vice-Chairman, Mr. W. H. Courtenay, Chief Engineer, Louisville & Nashville.)

Mr. Courtenay:—It is unfortunate that the keen interest of the Chairman of this Committee in the Panama Canal has prevented his appearance to-day.

The Vice-Chairman has an apology to make. The Committee requests that no consideration be given at this time to Conclusion (1) "That the revised specification for creosote oil be adopted for publication in the Manual." In the various meetings of the Committee, there was some misapprehension among different members as to the effect and purport of the modification of the specification for creosote oil. It is therefore the request of the Committee that the Association refer that conclusion back to the Committee for future consideration.

The Committee likewise would desire to withdraw from the consideration of the Association Appendix A. If this request of the Committee be approved, there only remains for consideration by the Association Conclusion (2) "That the two paragraphs, pp. 60 and 71, recommending the selection of a section of track for testing the life of ties, and recommending the framing of timbers before treatment be added to the recommended practice of the Association."

The President:—If there is no objection, the recommendation to the Committee, that Conclusion 1 be withdrawn, will be carried out. The purpose of that is to afford the Committee time for reconsidering the specifications for creosote oil. The Committee is willing under Conclusion 2, that the recommendation with reference to the selection of track for testing the life of ties be submitted to the Board of Direction for its action. If the convention is willing to turn that over to the Board of Direction without taking action here, it will be so ordered.

The recommendation of the Committee in Conclusion 2, that the framing of timbers before treatment be added to the recommended practice of the Association, is now the question before the convention. If there is no objection, it will be open for discussion.

Mr. C. E. Smith (Missouri Pacific):—I submit it is not practicable in all cases to frame the timbers, including the boring of holes, before treatment. It is possible to do so in many cases, but in a number of cases it is not. Take, for example, a cap on a pile bent. It would not be practicable to bore the holes for the connection of the sway-braces before they are put on. It would not be practicable to bore the holes for the chord bolt through the stringers. I think the Committee should specify a treatment for such surfaces of timber as must be worked in the field after the timbers have been treated.

The President:—Attention is called to page 71, last clause, "all bridge material intended for treatment should be framed, as far as possible, before timbers are placed in the treating cylinder. This includes the boring of the necessary holes." A portion of that clause answers Mr. Smith's question.

Mr. C. E. Smith:—The second point is that the Committee should be instructed to bring in a recommendation for the treatment of such surfaces as must be prepared in the field.

Mr. Courtenay:—The Committee is willing to consider that; the only thing that can be done is to mop such surfaces with creosote oil, which is a very simple process.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—Where it is necessary to bore holes in timber after they have been treated, if the holes are vertical, they should be plugged and filled with creosote, and the creosote allowed to soak in. Where it is necessary to frame small timbers which can be handled, it will be found the best treatment to immerse the framed end in hot creosote, permitting it to remain for about twenty minutes, taking it out, and immersing it in cold creosote, and permitting it to remain a similar length of time. That cannot be done where you saw off the end of piles, and in the case of large timbers—nothing but mopping can be done there; but the question in mind is one of such importance that something better than mopping should be insisted upon, if it is possible to do so.

Mr. Courtenay:—The Louisville & Nashville Railroad has been using creosoted timber in its trestle structures on a considerable scale since 1876. For that reason, our bridge supervisors have accumulated a great deal of experience with this material. We have adopted various expedients and endeavored, so far as possible, to frame creosoted material before it is creosoted, and have gone to the length of taking green timber, framing it, regularly erecting it in the structure, to insure a fit, and then taking it down to creosote it. After a long observation in the use of creosoted bridge timber, we find that good-heart yellow pine is almost impenetrable—that we can hardly get a penetration of the creosote of more than ¼ in. We have creosoted timber in these structures which has been there since 1876, and is apparently very good to-day. We have tried mopping the ends of creosoted timbers, cut in the field for framing, with hot creosote oil, and endeavored to get information about the efficiency of that by inquiry of our various supervisors of bridges and buildings over about fifteen divisions. There is a difference of opinion as to whether it is effective. Many say it is not effective, and others say that it is, but in the light of our experience, it is the best thing we have been able to devise, at reasonable cost, to protect timber which has had the outer creosoted portion cut through so as to expose the untreated wood.

Mr. C. E. Smith:—I would like to refer again to the matter. I do not think this Association should express its approval of putting frame timbers in a structure and then taking them out and shipping them to some point for treatment.

Mr. Courtenay:—That was not made as a recommendation of the Committee.

Mr. C. E. Smith:—I trust the Committee will amplify this portion of the subject by giving some method of treatment in the field.

Mr. J. B. Jenkins (Baltimore & Ohio):—I do not think the consideration of that should affect the adoption of this conclusion. This conclusion merely relates to framing as far as possible, and other cases can be taken care of by the Committee in subsequent reports. I move the adoption of this section.

The President:—It is, nevertheless, a matter of great importance to the members of the Association. We can spend a lot of money creosoting our material, and then, if we cut it up in the field and practically destroy the effectiveness of the creosoting treatment, that is not true economy.

Mr. McDonald:—If Mr. Robinson is present, I would like him to describe the success he has had in the mopping of the heads of piles on the Galveston viaduct.

Mr. C. F. W. Felt (Santa Fe):—Being called upon in the absence of Mr. Robinson, I will say that this is a case where we used the Marine treatment. We have had no trouble with decay at that bridge. We used the 24-lb.-per-cubic-foot treatment. It is our rule to mop the timbers with hot creosote and also with asphalt on the ordinary creosoted trestle or ballast deck construction.

Mr. Courtenay:—If the Association wishes to give the time, I will give some information. In 1882 a pier was constructed at Pensacola, Florida. Alongside of that pier there were a number of mooring piles standing high above the pier. The tops of the piles were exposed to the sun. They were necessarily cut off to the proper height above the top of the pier. The tops of the piles were mopped with creosote oil, and in addition had a thick covering of hot pitch, and we mixed some lime with it. In 1887 the heart-wood in the tops of a number of these mooring piles was so rotten that a man could pick out a conical-shaped plug with his fingers. Other piles lasted much better. Nearly all of them are exposed to the rays of the sun. When a pile is creosoted, and driven, and the top of the pile is cut off to get proper bearing for the cap, the top of the pile under these conditions does not rot. We had creosoted timber, heart pine, put in trestle structures between Mobile and New Orleans, covered with 2 ft. of sand, put there in 1886, and the timber is good to-day. As far as I know, they are the first ballasted deck trestles constructed. Creosoted wood, placed in such a manner as to be protected from the action of the sun, will last longer than when not so protected. Our experience is that spike holes in the sides of the piles will not hurt them much, but if the piles are sized after being treated and driven, in order to make the bracing fit better, they are greatly injured.

The President:—If there is no further discussion, the Committee will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE I.—ON ROADWAY.

(Bulletin 131.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Roadway respectfully submits its twelfth annual report.

Subjects assigned by the Board of Direction to the Committee were as follows:

(1) Consider revision of the Manual; if no changes are recommended, make statement accordingly.

(2) Collect all known formulas for determination of size of waterways and tabulate them in such manner that they may be intelligently compared. Also consider whether, by the introduction of factors suiting local conditions, a general formula for waterway areas could not be used in all cases.

(3) Unit pressures allowable on the roadbed of different materials.

(4) Tunnel construction and ventilation.

(5) Investigate and report on the question of agricultural drainage in levee and marsh districts as they affect railroads:

(a) Laws and assessments.
(b) Methods of construction of drainage channels through railroads.

(6) Make concise recommendations for next year's work.

Sub-committees were appointed to consider the different subjects, as follows:

(1) Revision of Manual:
S. B. Fisher, Chairman;
Duncan MacPherson,
J. R. W. Ambrose,
H. J. Slifer.

(2) Formula for Waterways:
W. D. Pence, Chairman;
John C. Beye,
J. A. Spielmann.

(3) Unit Pressures on Roadbed:
W. M. Dawley, Chairman;
Moses Burpee,
J. G. Sullivan,
Walt Dennis.

(4) Tunnel Construction and Ventilation:
J. E. Willoughby, Chairman;
D. J. Brumley,
C. Dougherty,
W. P. Wiltsee.

(5) Drainage Districts:
W. C. Curd, Chairman;
R. C. Young,
Paul Didier,
J. C. Sesser.

(6) Recommendations for 1911:

The entire Roadway Committee to consider this subject and each member to send suggestions to the Chairman.

The sub-committees report progress during the year as follows:

(1) REVISION OF THE MANUAL.

The Sub-Committee, S. B. Fisher, Chairman, has several changes to suggest for the Manual, more especially in the matter of revising definitions, and would report progress. The Committee expects to make its recommendations in the future.

(2) FORMULAS FOR WATERWAYS.

The Sub-Committee on Formula for Waterways has made a very thorough investigation of all known formulas and reports as follows:

SIZE OF WATERWAYS.

The instructions of the Board of Direction to the Roadway Committee (Bulletin No. 122, April, 1910) include the following item relating to the determination of the size of waterways for culverts and bridges:

"Collect all known formulas for determination of size of waterways and tabulate them in such a manner that they may be intelligently compared. Also consider whether, by the introduction of factors suiting local conditions, a general formula for waterway areas could not be used in all cases."

Acting under substantially these same instructions during the previous year, the sub-committee charged with this matter compiled a large amount of valuable material,* much of it then freshly gathered from the members of the Association, relating to current practice in connection with fixing the size of waterways. As a result of the studies made up to that time the Roadway Committee submitted to the annual convention in March, 1909, the following preliminary or tentative conclusions which were adopted by the Association:

"(1) In determining the size of a given waterway, careful consideration should be given to local conditions, including flood height and flow, size and behavior of other openings in the vicinity carrying the same stream, characteristics of the channel and of the watershed area, climatic conditions, extent and character of traffic on the given line of road and probable consequences of interruptions to same, and any other elements likely to affect the safety or economy of the culvert or opening.

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*See Proceedings, Vol. 10 (1909), pp. 967-1022.

"(2) (a) The practice of using a formula to assist in fixing the proper size of the waterway in a given case is warranted to the extent that the formula and the values of the terms substituted therein are known to fit local conditions.

"(b) Waterway formulas are also useful as a guide in fixing or verifying culvert areas where only general information as to the local conditions is at hand.

"(c) The use of such formulas should not displace careful field observation and the exercise of intelligent judgment on the part of the engineer.

"(d) No single waterway formula can be recommended as fitting all conditions of practice."

The concluding paragraph (d) of the foregoing conclusions represented the practically unanimous opinion of the members of the Roadway Committee, but it seemed desirable in view of the widespread interest displayed in the inquiry that the matter should be the subject of some further study. To this end it was suggested to the Board that the topic should again be assigned, and this was done, as already indicated.

The studies during the past year have taken the form of an extended library search made for the purpose of bringing together "all known formulas for determining the size of waterways" as nearly as practicable in conformity with the Board's instructions. After some discussion, approval was given to the plan of undertaking these further compilations through the medium of a thesis investigation under the direction of Prof. W. D. Pence, chairman of the sub-committee having the investigation in charge, the work being performed by A. F. Gilman and G. W. Chamberlin, senior students in civil engineering in the University of Wisconsin (1909-1910). The results of their investigations, in somewhat condensed form, is submitted as Appendix A to the present report. The inquiry began with a general survey of the literature of the subject, and this was supplemented among other features by a critical examination into the merits of the so-called "Dun Waterway Data" as a means of approach to the derivation of the general waterway formula contemplated in the Board's instructions.

Although the matter thus brought together is lacking in completeness in certain of its aspects, the results were deemed worthy of preservation in permanent form as a progress report upon the subject, especially in view of the increasing interest displayed in this matter by engineers engaged both in the dimensioning of proposed new structures for carrying water through the roadbed and in defending their older structures under the fire of court attack.

Your Committee, after careful consideration of the results of its further investigations, although not prepared to modify the conclusions heretofore submitted to the Association that "no single waterway formula can be recommended as fitting all conditions of practice," nevertheless

THE DUN DRAINAGE TABLE.

Atchison, Topeka & Santa Fe Railway System (1906).

Areas Drained in Square Miles.	AREAS OF WATERWAY.						
	Missouri and Kansas.	Cast Pipe. Banks over 15 ft. Use 80 per Cent.	Box and Arch Culverts. 1st Fig. = Diam. 2d. Fig. = Bench	PERCENTAGE OF COLUMN 2.			
				Illinois.	Indian Territory.	Texas.	New Mexico.
1	2	3	4	5	6	7	8
.01	2.0	1-24 in.	2 x 1 B	East of Streator use 60 per cent.	South of Purcell use Texas Column.	Use Column 2.	Use Column 2.
.02	4.0	1-24 "	2 x 2 "				
.03	6.0	1-30 "	2 x 3 "				
.04	7.5	1-36 "	2½x3 "				
.05	9.0	1-42 "	3 x3 "				
.06	10.5	1-42 "	3½x3 "				
.07	12.0	1-48 "	3 x4 "				
.08	13.5	2-36 " D	2½x3 "				
.09	15	2-36 " "	2½x3 "				
.10	16	2-36 " "	3 x3 "				
.15	25	2-48 " "	3 x4 "				
.20	32	3-42 "	6 x4 A				
.25	38	3-48 "	6 x5 "				
.30	44	....	6 x5½ "				
.35	51	....	8 x4½ "				
.40	56	....	8 x5 "				
.45	62	....	8 x6 "				
.50	66	....	8 x6 "				
.55	70	....	8 x6½ "				
.60	74	....	10 x4½ "				
.65	78	....	10 x5 "				
.70	81	....	10 x5½ "				
.75	85	....	10 x6 "				
.80	88	....	10 x6½ "				
.85	91	....	10 x6½ "				
.90	94	....	10 x6½ "				
.95	97	....	12 x5 "				
1.0	100	....	12 x5 "	West of Streator use 80 per cent.	North of Purcell use Column 2.		98½
1.1	110	....	12 x6 "			105	98½
1.2	120	....	12 x7 "			105	98½
1.3	130	....	12 x8 "			105	98½
1.4	140	....	14 x6½ "			105	98½
1.5	150	....	14 x7 "			105	98½
1.6	160	....	16 x6½ "			105	98½
1.7	170	....	16 x7 "			105	98½
1.8	180	....	16 x7½ "			105	98½
1.9	190	....	16 x8 "			105	98½
2.0	200	....	18 x7 "			105	98½
2.2	220	....	18 x8 "			105	98½
2.4	240	....	18 x9½ "			105	98½
2.6	260	....	20 x8 "			105	98½
2.8	280	....	20 x9 "			105	98½
3.0	300	....	20 x9½ "			105	98½
3.2	321	....	22 x8½ "			105	98½
3.4	340	....	22 x9 "			105	98½
3.6	357	....	24 x8½ "			105	98½
3.8	373	....	24 x9 "			105	98½
4.0	388	....	28 x7 "			105	97
4.2	403	....	28 x7½ "			105	97
4.4	417	....	28 x8 "			105	97
4.6	430	....	28 x8½ "			105	97
4.8	443	....	28 x9 "			105	97
5 0	455	....	28 x9½ "			105	97
5.5	483	....	28 x10 "	West of Streator use 80 per cent. East of Streator use 60 per cent.	North of Purcell use Column 2. South of Purcell use Texas Column.	105	97
6.0	509	....	32 x7½ "			105	97
6.5	533	....	32 x8 "			105	97
7.0	556	....	32 x9 "			105	97
7.5	579	....	32 x10 "			105	97
8.0	601	....	32 x11 "			105	97
8.5	622	....	32 x11½ "			105	97
9.0	641	....	32 x12 "			105	93½
9.5	660	....	32 x12½ "			105	93½
10	679	....	32 x13 "			105	93½
11	710	....	Bridges designed to provide area according to circumstances.			105	93½
12	740	....				105	93½
13	775	....				105	93½
14	805	....				105	93½
15	835	....				105	93½
16	865	....				105	94
17	890	....				105	94
18	920	....				105	94
19	945	....				105	94
20	970	....				105	94
22	1,015	....				105	94

Areas Drained in Square Miles.	AREAS OF WATERWAY.				
	Missouri and Kansas.	PERCENTAGE OF COLUMN 2.			
		Illinois.	Indian Territory.	Texas.	New Mexico.
1	2	5	6	7	8
24	1,060	East of Streator use 60 per cent.	South of Purcell use Texas Column.	110	94
26	1,100			110	92
28	1,140			110	92
30	1,180			110	92
32	1,220			110	92
34	1,255			110	92
36	1,290			110	91
38	1,320			110	91
40	1,350			110	91
45	1,435			110	91
50	1,510			110	89½
55	1,580			115	89½
60	1,650			115	89½
65	1,720			115	88
70	1,780			115	88
75	1,840			115	88
80	1,900			115	86½
85	1,960			115	86½
90	2,015			115	86½
95	2,065			115	86½
100	2,120			120	85
110	2,220			120	85
120	2,315			120	85
130	2,405			125	83½
140	2,500			125	83½
150	2,580			130	82
160	2,665			130	82
170	2,745	West of Streator use 80 per cent.	North of Purcell use Column 2.	130	80½
180	2,820			130	80½
190	2,900			130	79
200	2,970			130	79
220	3,115			130	77½
240	3,245			130	77½
260	3,370			130	76
280	3,495			130	76
300	3,615			130	74½
325	3,770			130	74½
350	3,900			130	73
375	4,035			130	73
400	4,165			130	71½
450	4,385			130	70
500	4,610			130	68½
550	4,825			130	67
600	5,030			130	65½
650	5,230			130	64
700	5,420			130	62½
750	5,610			130	61
800	5,800			130	59½
850	5,890			130	58
900	6,080			130	56½
950	6,230			130	....
1,000	6,380	West of Streator use 80 per cent. East of Streator use 60 per cent.	North of Purcell use Column 2. South of Purcell use Texas Column.	130	....
1,100	6,705			130	....
1,200	6,960			130	....
1,300	7,230			130	....
1,400	7,480			130	....
1,500	7,725			130	....
1,600	7,960			130	....
1,700	8,195			130	....
1,800	8,390			130	....
1,900	8,625			130	....
2,000	8,820			130	....
2,200	9,240			130	....
2,400	9,605			130	....
2,600	9,970			130	....
2,800	10,320			130	....
3,000	10,640			130	....
3,500	11,445			130	....
4,000	12,160			130	....
4,500	12,825			130	....
5,000	13,500			130	....
5,500	14,080			130	....
6,000	14,520			130	....
6,500	15,140			130	....

The above classification by states is for convenience only, and merely denotes the general characteristics of topography and rainfall.

Column 2 in this table is prepared from observations of streams in Southwest Missouri, Eastern Kansas, Western Arkansas and the southeastern portions of the Indian Territory. In all this region steep, rocky slopes prevail and the soil absorbs but a small percentage of the rainfalls. It indicates larger waterways than are required in Western Kansas and level portions of Missouri, Colorado, New Mexico and Western Texas.

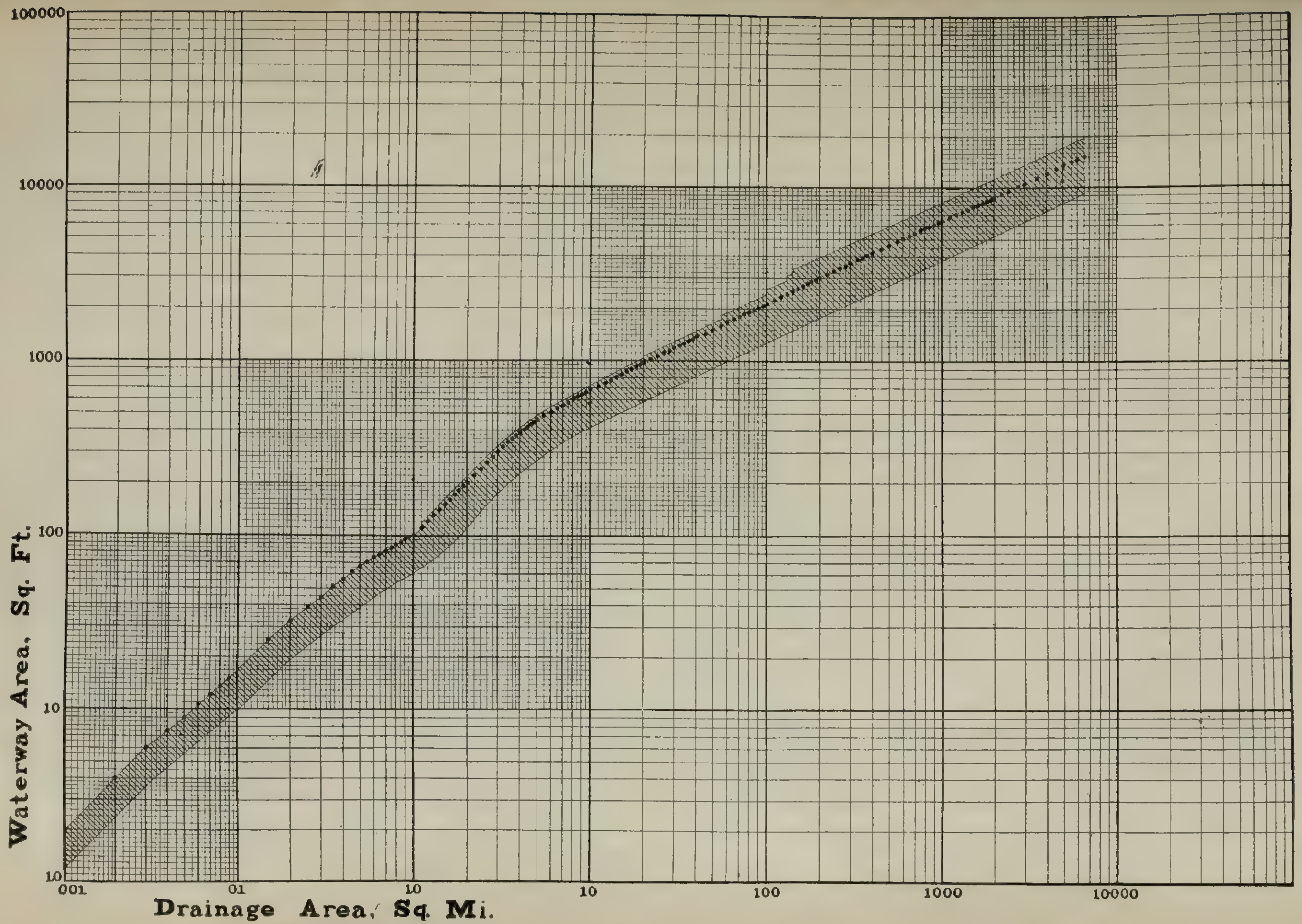

FIG. 1. DIAGRAM OF DUN'S WATERWAY DATA—SANTA FE SYSTEM PRACTICE.

feels warranted in calling particular attention to certain relationships which give much promise in the direction of such general formula. The relationships referred to are best illustrated by introducing a graphical chart of the waterway data gathered by the late James Dun in his exhaustive analysis of the practice of the Santa Fe System, covering many years' observation of the behavior of actual waterway openings under the widest possible range of conditions. These Dun figures are reproduced in numerical form in Table 1, and graphically in Fig. 1, covering the remarkable sweep of watershed area ranging from 0.01 square mile (6.4 acres) to 6,500 square miles (4,000,000 acres), and of waterway areas from 2 square feet to upward of 15,000 square feet cross-section.

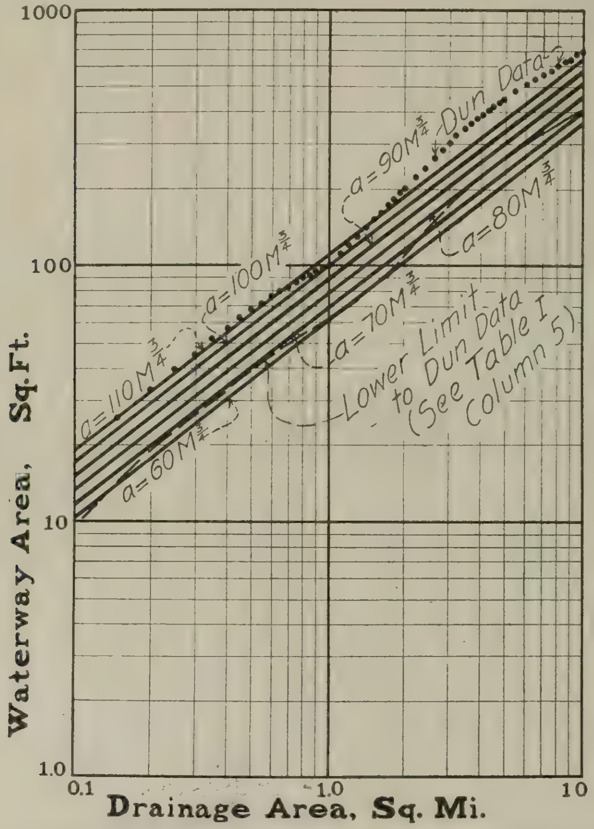

FIG. 2. SUGGESTION AS TO GENERAL RELATIONSHIP OF WATERWAY FORMULAS PROPOSED BY VARIOUS AUTHORITIES.

In attempting to reconcile the widely varying values of exponents applied to the values of watershed areas in the various formulas proposed for calculating culvert areas, it has been suggested in a previous report of this Committee (1909 Proceedings, p. 976) that the various authorities may have been dealing with run-off data observed from watershed areas of widely varying characteristics and shapes. The basis of this suggestion is illustrated in Fig. 2, where the roughly drawn curve is intended to represent in a hypothetical or tentative way the general relationship referred to.

Fig. 3 is likewise submitted to illustrate graphically the effect of a variation in the value of the coefficient for a given value of the exponent; the exponent used in this case being three-fourths (¾), the value adopted by Talbot in his adaptation to American railway practice (1887) of the run-off formula of the Swiss engineer Burkli-Ziegler (1880).

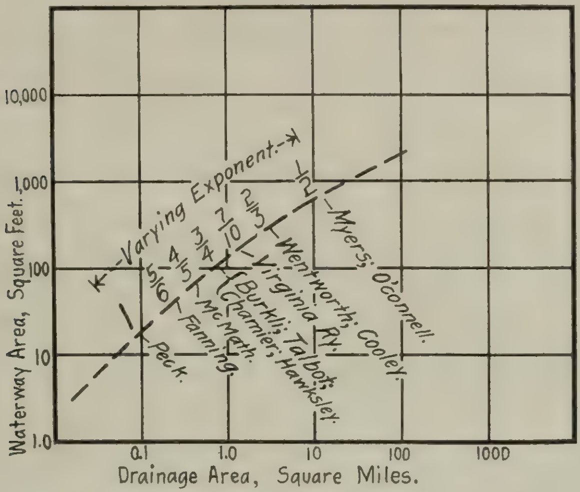

FIG. 3. DIAGRAM SHOWING EFFECT OF VARYING VALUE OF COEFFICIENT IN WATERWAY FORMULA.

It should be stated that the Committee has not, as yet, given more than casual consideration to the hydraulic features of the culvert proper. It is respectfully suggested that in the assignment of work for the coming year that phase of the subject be assigned to this Committee for investigation, with liberty to report further progress, if any, with reference to the general waterway formula contemplated in the Board's instructions for the past two years.

CONCLUSIONS.

From the foregoing discussion, your Committee submits the following conclusions:

(1) There is a general relationship between the best-known waterways and run-off formulas. This relationship may be expressed by two terms, a varying coefficient and a varying exponent, substantially as shown by the accomapnying diagrams, Figs. 2 and 3.

(2) The extent of this relationship for large and small areas is indicated by the Dun waterway data given in Table 1 and shown graphically by Fig. 1.

(3) UNIT PRESSURES ON ROADBED.

This Sub-Committee has compiled considerable data and will hold a joint meeting with the Ballast Committee to consider this subject on Monday, March 20, 1911. Their data with the conclusions of the Committee will probably be published in a later Bulletin.

(4) TUNNEL CONSTRUCTION AND VENTILATION.

This Sub-Committee would report progress and expects very soon to issue a circular to the Association requesting information in regard to current practice.

(5) DRAINAGE DISTRICTS.

The Sub-Committee dealing with this subject has made an exhaustive study of the laws of the various States and has compiled a complete list of the laws of the following states:

Arkansas, Alabama, Arizona, Florida, Georgia, Virginia, Kentucky, Idaho, Maine, Texas, New Mexico, Tennessee, Mississippi, New York, Michigan, South Carolina and North Carolina.

The following States have no drainage laws in effect:

Colorado, Connecticut, Massachusetts, New Hampshire, Rhode Island, Utah, Vermont and Wyoming.

As these laws are very voluminous, the Committee decided not to publish them in the Proceedings until they have been abstracted, and the Sub-Committee is now making up a compilation with that portion of the laws which affects railroads. This we also hope to publish in a later Bulletin.

(6) RECOMMENDATIONS FOR 1911.

The Committee would recommend continuing each of the subjects assigned for the past year, with the exception of Sub-Committee II—Formula for Waterways, and for this the Committee would substitute the study of "Hydraulic Features of Culverts and Waterways," to be continued as a supplement to the subject, "Formula for Waterways."

During the year there have been two meetings of the General Committee, one on November 29, which was attended by the following members: W. D. Pence, J. E. Willoughby, W. P. Wiltsee, R. C. Young and G. H. Bremner.

On December 30 the General Committee held a joint meeting with the Committee on Iron and Steel Structures, under instructions from the Board of Direction to bring about a joint recommendation to the Association as to the point from which clearances should be adopted. At this meeting the following members of the two committees were present: G. H. Bremner, Chairman of the Roadway Committee; S. B. Fisher, Vice-Chairman of the Roadway Committee; C. H. Cartlidge, Chairman of the Committee on Iron and Steel Structures, and J. A. Bohland, of the latter Committee. At this meeting it was concluded to recommend to the

Board of Direction that in the report of the Committee on Iron and Steel Structures there be added to paragraph 2 of the specifications the following:

"The height of rail shall, in all cases, be assumed as six inches."

In the report of the Committee on Roadway and the conclusions printed therefrom and submitted to the Association for approval, we would recommend that the same words be added at the end of paragraph 1, and that in the diagrams the dimension six inches from top of rail to top of tie be inserted.

Respectfully submitted,

Geo. H. Bremner, Engineer, Illinois District, Chicago, Burlington & Quincy Railway, Chicago, Ill., *Chairman.*

S. B. Fisher, Chief Engineer, Missouri, Kansas & Texas Railway, St. Louis, Mo., *Vice-Chairman.*

J. R. W. Ambrose, Assistant Engineer, Grand Trunk Railway, Montreal, Canada.

John C. Beye, Locating Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

D. J. Brumley, Engineer of Construction, Illinois Central Railroad, Chicago, Ill.

Moses Burpee, Chief Engineer, Bangor & Aroostook Railroad, Houlton, Maine.

W. C. Curd, Assistant Engineer, Missouri Pacific Railway, St. Louis, Mo.

W. M. Dawley, Assistant Engineer, Erie Railroad, New York, N. Y.

Walt Dennis, Office Engineer, Kansas City Southern Railway, Kansas City, Mo.

Paul Didier, Principal Assistant Engineer, Baltimore & Ohio Railroad, Allegheny, Pa.

C. Dougherty, Chief Engineer, Cincinnati, New Orleans & Texas Pacific Railway, Cincinnati, Ohio.

Duncan MacPherson, Assistant Chief Engineer, National Transcontinental Railway, Ottawa, Ont.

W. D. Pence, Professor of Railway Engineering, University of Wisconsin, Madison, Wis.

John C. Sesser, Assistant Engineer Maintenance of Way, Great Northern Railway, St. Paul, Minn.

H. J. Slifer, General Manager, Chicago Great Western Railroad, Chicago, Ill.

J. A. Spielmann, Engineer Maintenance of Way, Baltimore & Ohio Railroad, Wheeling, W. Va.

J. G. Sullivan, Assistant Chief Engineer, Canadian Pacific Railway, Winnipeg, Man.

J. E. Willoughby, Engineer of Construction, Louisville & Nashville Railroad, Louisville, Ky.

W. P. Wiltsee, Assistant Engineer, Norfolk & Western Railway, Roanoke, Va.

R. C. Young, Chief Engineer, Lake Superior & Ishpeming and Munising Railways, Marquette, Mich.

Committee.

Appendix A.

WATERWAY FOR CULVERTS.

(This paper is a digest of the material compiled in the course of a thesis investigation by A. F. Gilman and G. W. Chamberlin in 1909-1910, under the direction of Prof. W. D. Pence, University of Wisconsin. The investigation consisted in its initial stage of a library search for waterway and run-off formulas and related matter, with a view of throwing some light on the derivation of a formula for general application, as indicated in the instructions of the Board of Direction to the Roadway Committee. Upon completing the library search for formulas the investigation was turned in the direction of reconciling the various conflicting features, the Dun waterway data, based upon Santa Fe System practice, being taken as a tentative basis of reference. Much of the digest given below consists of a mere outline of the original draft of the thesis.)

HISTORICAL.

To avoid needless repetition only the major headings are here given. Reference is made to the review of the literature of the subject to be found in the report of the Roadway Committee, Proceedings (1909), Vol. 10, pp. 967-978. The principal steps in the development of current practice on American railroads of using formulas as a guide to the judgment in fixing the size of culvert areas are the following:

1879—The first published reference to the simple waterway formula proposed by Major E. T. D. Myers, contained in a paper by Cleeman before the Engineers' Club of Philadelphia.

1881—First reference in American technical literature to the run-off formula of the Swiss hydraulic engineer, Burkli-Ziegler, in report on "Sewerage Works in Europe," by Hering, to the National Board of Health.

1886—Discussion of Myers formula and of the use of waterway formulas in general by Wellington in editorial in Railroad Gazette; and in 1887, discussion by same authority on the economics of culvert dimensions, in "Economic Theory of Railway Location" (pp. 781-783).

1887—First publication by Prof. A. N. Talbot of his formula for culvert areas, based on the Burkli-Ziegler formula, in the Selected Papers of the Civil Engineers' Club, University of Illinois.

1897—Report of Committee on Waterway for Culverts, W. G. Berg, chairman, in Proceedings of American Railway Bridge and Building Association.

1906—Symposium on methods of determining the size of waterway for culverts, by G. H. Bremner, James Dun and others, in Journal of the Western Society of Engineers.

1909—Report of Roadway Committee on water for culverts, in Proceedings of American Railway Engineering and Maintenance of Way Association, including a "Digest of Current Practice," freshly gathered from the members of the Association (pp. 978-1022).

COMPILATION OF FORMULAS.

The following compilation of formulas for culvert areas and for the determination of run-off is believed to include all the better known formulas besides several not customarily used by American railroad engineers. The references indicate as a rule the date and place of first publication, the brief explanatory comments for the most part being roughly quoted from the original articles. The nomenclature is taken without change from the original sources.

The Myers Formula.[1]

$$A = c\sqrt{M}.$$

where $A =$ the area of waterway required, in square feet.
$M =$ the area drained, in acres.
$c = 1$ as a minimum for flat country.
$c = 1.6$ for hilly compact ground.
$c = 4.0$ as a maximum for mountains, rocky country.

As already stated, Major Myers recommended this formula as applying well to the water courses which he had been able to examine, which lay chiefly on the line of the Richmond, Fredericksburg & Potomac Railroad.

The Talbot Formula.[1]

$$A = c\sqrt[4]{M^3}.$$

where $A =$ the waterway area necessary, in square feet.
$M =$ the area drained, in acres.

This formula is not intended for use for drainage areas of more than 400 square miles. It was derived with especial reference to areas under 77 square miles in size. As quoted previously: "For rolling country subject to floods at a time of melting snow, and with a length of valley three or four times the width, let c be one-third. For valleys with stream longer in proportion to the area, decrease c. In districts not affected by accumulated snow and where the length of the valley is several times the width, one-fifth or one-sixth or even less may be used. For steep side slopes, especially where the upper part of the valley has a much greater fall than the channel at the culvert c should be increased."

This formula is used very generally in the southwestern and western portion of this country and appears to give excellent results for the smaller areas.

The Peck Formula[1] (better known as the Missouri-Pacific formula):

$$\text{Area of waterway in square feet} = \frac{\text{Drainage area in acres.}}{c}$$

c varies from 4 to 6, depending on the country.

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[1] Proceedings Engrs. Club, Phila., Vol. I, p. 146, April 5, 1879.
[1] Selected Papers, Civil Engrs. Club, Ill. Univ., No. 2, p. 14, May 28, 1887.
[1] Proceedings Amer. Ry. B. & B. Assn., 1897, pp. 86-100.
[2] Letter to the editor of the Ry. Gaz., 1903, p. 57.

In very mountainous country, where slopes of hills and mountains are steep and abrupt, c is equal to 4. In ordinary flat rolling country, such as is found in good agricultural sections, c is equal to 6.

The Wentworth Formula.[2]

$$a = d^{\frac{2}{3}}$$

where a = the sectional area of the waterway, in square feet.

d = the drainage area, in acres.

This formula was derived in connection with work on the Norfolk & Western Railway and is especially fitted to the conditions along that line, and in general to the conditions in the Southeastern States. In cases of less rainfall, or if the ground be quite flat, the author states that the two-thirds power of the drainage area is too great for the square feet of area needed in the waterway. In the observations of Mr. Wentworth, 60 per cent. of the resulting area may be taken as the lower limit.

The Murphy Formula.[1]

$$A = \frac{Q}{V} = \frac{Q}{C\sqrt{RS}}$$

where A = area of waterway, in square feet.

V = mean velocity, in feet, per second.

R = hydraulic radius = range in stage in time of flood. (See explanation below.)

$$c = \frac{a + \frac{b}{n} + \frac{c}{S}}{1 + \left(a + \frac{c}{S}\right)\frac{n}{\sqrt{R}}}$$

where a, b, and c are constants and n is the coefficient of roughness of the bed.

S = slope of surface.

"It can be shown that the hydraulic radius

$$R = \frac{A}{P} = \left(\frac{(I + 2d)X}{(I + 2d)\sqrt{(1 + X^2)^{\frac{1}{2}}}}\right)d \ldots\ldots\ldots\ldots (3)$$

in which I is the bottom width of a trapezoidal section, d is the depth and X is the slope of the sides. It can be seen from equation (3) that for any given values of d and X, R approaches d as I increases; for the case of floods, therefore, it may be assumed that R = the difference in stage between high and ordinary low water."

"This method of finding the waterway at a given place on a stream consists in finding the drainage area in square miles above the place under consideration, the greatest change in stage of the stream at this place and the slope of the surface. By multiplying the drainage area M by q (the maximum discharge in second-feet per square mile that is to be expected in that portion of the country), we find Q; dividing Q by V using for R the maximum range of stage, and for S the measured slope of surface of the stream, we have the necessary area of waterway. The greatest error in the use of this method will result from an incorrect measurement of the slope. The formula calls for the slope of surface, and surface slope of a stream is not necessarily the slope of the bed. The slope is not the same at all stages nor always the same for a given stage. If the place under consideration is near the mouth of a large tributary the slope of the main stream will be affected by the stage of the tributary. Overflow and flooding of lowlands is frequently the result of backwater, due to reduction of surface slope. The smaller the slope used the greater will be the computed waterway. If there is a possibility of the waterway becoming partly clogged with drift, logs or ice, or its being in the influence of backwater from a tributary, the computed area must be increased by a liberal amount."

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[1] "Destructive Floods in the United States, 1904," by E. C. Murphy, pp. 189-193. U. S. Geol. Surv. Water Supply Paper, No. 147, 1905.

The Dun Data.[1]

A reproduction of the 1906 table may be found in the accompanying Table I. This data was derived principally from observations made along the lines of the Santa Fe Railway in Missouri, Kansas, Indian Territory and Texas.

The C., B. & Q. Formula.[2]

$$Q = \frac{3000\,M}{3 + 2\sqrt{M}}$$ or using V = 10 ft. per second.

$$A = \frac{300\,M}{3 + 2\sqrt{M}}$$

where $Q =$ the total discharge from the area in cubic feet per second.

$M =$ the drainage area, in square miles.

$A =$ the waterway in square feet, using the velocity through the culvert as 10 ft. per second.

The Cooley Formula.[3]

No. 1. $Q = 200\,M^{2/3}$, or $A = 20\,M^{2/3}$.

No. 2. $Q = 180\,M^{2/3}$, or $A = 18\,M^{2/3}$.

Notation is the same as for C., B. & Q. formula.

The Tidewater (Virginia) Railway Formula.[4]

$$A = 0.62\,M^{7/10},$$

where $M =$ area drained (watershed) in acres.

$A =$ Neat area of waterways, in square feet.

"Where the stream has a flat fall, add 30 per cent.; where double openings are used, add 20 per cent. to total cross-section area."

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[1] Appeared first in blue print form in 1897, and in its present full form in 1906 in the Jour. Wes. Soc. Engrs., p. 146.

[2] Reference to this formula may be found in Mr. Bremner's paper before the Wes. Soc. of Engrs. in 1906, Vol. 11, p. 139.

[3] Jour. Wes. Soc. Engrs., Vol. 11, p. 139.

[4] Tidewater Railway "Tables and Data for Estimates and Comparisons," Roanoke, Va., January, 1905. (Blue print.)

The El Paso & South Western Railway Formula.

$$Q = 17\sqrt{\frac{8000}{A}}$$

where $Q =$ the maximum run-off per square mile of drainage area.
$A =$ the total drainage area in square miles.

This is practically the formula by Mr. Joseph P. Frizell, which he worked up from the records of flow over the Holyoke dam, Massachusetts, for a period of 50 years, and it appears in the original form in his book on hydraulics.

As a check on this formula the following table is used. It follows Dun's data very closely and appears to have been worked up from the Santa Fe table:

Drainage Area, Square Miles.	Waterways,* Square Feet.	Drainage Area, Square Miles.	Waterways,* Square Feet.
0.12	18.8	4.6	353
0.22	31.4	5.8	428
0.40	51.0	7.2	508
0.70	74.0	9.5	628
1.15	102.0	12.4	756
1.55	134.0	15.8	878
2.00	170.0	19.9	978
2.50	209.0	24.6	1,088
3.50	280.0	30.2	1,199

The Lauterberg Formula.[1]

$$\text{Average discharge of a river} = \phi = \frac{1{,}000{,}000}{31{,}530{,}000}\,ChF$$
$$= 0.03171\,ChF$$

where $\phi =$ average quantity discharged per second.
$F =$ the area drained in square kilometers.
$h =$ the total yearly rainfall in inches.
$c = 0.20$ for marshy soil.
$= 0.25$ for level plains.
$= 0.30$ for rolling ground.
$= 0.35$ for low hills.
$= 0.45$ for hilly country like the Ardennes, the Odenwald and the Eifel.
$= 0.55$ for the Black Forest and the Vosges.
$= 0.70$ for high rocky mountains.

Lauterberg endeavored to frame a rational estimate as to the probable discharge of streams by means of the above formula, which is based upon data collected in Switzerland.

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*"Waterway in sq. ft. required on steep, rocky slopes where very little rainfall is absorbed. To be multiplied by co-efficient c greater than 1 for exceedingly mountainous country, and less than 1 for comparatively level country. C may vary from 0.50 for flat country with porous soil to 1.50 for rocky, mountain gorges."

[1] Abstract in the Proceedings Inst. C. E., Vol. 149, p. 392, 1887, from Lauterberg's "Schweizerische Stromabflussingen." Bern, Huber & Co., 1876.

The Fanning Formula.[2]

$$Q = 200\,M^{5/6}$$

where M is the area of watershed in square miles and
Q is the volume of discharge in cubic feet per second.

The Dredge Formula.[1]

$$Q = 1300 \frac{M}{L^{2/3}}$$

Notation the same as in the Fanning formula.
L = the length of drainage area in miles.

The Dickens Formula.[2]

$$Q = c \times 27\,M\overset{3/4}{2}.$$

$Q = 200\,M^{3/4}$, for Madras Presidency, India.
$Q = 500\,M^{3/4}$, for Central Provinces, India.
$Q = 825\,M^{3/4}$, for Bengal and Bahar, India.
$Q = 1{,}200\,M^{3/4}$, for Upper Kaveri, India.
$Q = 2{,}200\,M^{3/4}$, for Gadamatti, India.

The O'Connell Formula.[3]

$$Q = 458\,[\sqrt{(640\,M + 4.58)} - 45.8].$$

This formula is best adapted to small districts.
The notation is the same as that of the Fanning formula.

The Kutter Formula[1] (derived by Ganguillet and Kutter in 1869).

$$Q = \frac{1421\,M}{0.311 + \sqrt{M}}$$

This formula is adapted to Swiss streams. The notation is the same as that of the Fanning formula.

The Hering Formula.[3]

$$Q = \frac{D\,M\,v}{L} \text{ or } \frac{D\,M\,v}{t_1}$$

where Q and M are the same as those of the Fanning formula and
L = the length of the river.
v = the mean velocity of the stream.
D = the entire depth of rain flowing off during a storm.
t_1 = the time taken for a drop of water falling near the periphery of watershed to reach the culvert.

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[2] Fanning's "Water Supply Engineering," 1878, p. 66.

[1] Fanning's "Water Supply Engineering," 1878, p. 66. Taken from the "Indian Professional Papers."

[2] Fanning's "Water Supply Engineering," 1878, p. 66.

[3] Proceedings Inst. C. E., Vol. 27, 1868.

[1] Proceedings Inst. C. E., Vol. 71, 1883.

[3] Proceedings Engrs. Club of Phila., Vol. 1, p. 146, 1879.

The Possenti Formula.[2]

$$Q = c_2 \frac{R}{L_1}\left(M_2 + \frac{M_1}{3}\right)$$

c_2 = a coefficient with an average value of 1,010.

R_1 = the depth of rainfall in inches for 24 hours.

M_2 = the area of hilly or mountainous part of watershed, in square miles.

M_1 = the area of level or flat part of watershed, in square miles.

L_1 = the length in miles of the stream from its source to the point of observation.

This formula applies especially to mountain streams of moderate size in the Appenines.

The Burkli-Ziegler Formula.[1]

$$q = c\,r\,\sqrt[4]{s/a}$$

where q = the water reaching the sewer in cubic feet per acre per second.

r = the average intensity of rain during heaviest fall in cubic feet per acre per second.

s = the general grade of the drainage area in feet per hundred.

a = the area drained, in acres.

c = a coefficient, for average areas it equals 0.625.

The observations extended up to slopes of 10 ft. per 100, but were limited to small areas of less than 50 acres. This formula is especially applicable to sewer design.

The Coghlan Formula.

$$P = tc\,R^{1.9}$$

where P = the inches of rainfall discharged by stream.

t = a coefficient for time, the value of which is governed by the length of time the freshet lasts.

c = a coefficient of rainfall varying with the quantity of rain.

R = the average daily rainfall in inches during the freshet.

This formula is applicable to drainage districts of moderate size in New South Wales.

The following values of t and c and given by the author:

Length of freshet in days....350	Value of t in inches....2.6
Length of freshet in days....300	Value of t in inches....2.5
Length of freshet in days....250	Value of t in inches....2.4
Length of freshet in days....200	Value of t in inches....2.2
Length of freshet in days....150	Value of t in inches....2.1
Length of freshet in days....100	Value of t in inches....2.0
Length of freshet in days.... 50	Value of t in inches....1.9
Length of freshet in days.... 25	Value of t in inches....1.8

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[2] Markus, "Meliorationswesen in Italien," Vienna, 1881.

[1] This formula was derived by Burkli-Ziegler in 1880 and brought to this country by Rudolph Hering in 1881. See Report National Board of Health, 1881; also Trans. Amer. Soc. C. E., Vol. 10, p. 362.

Rainfall in inches............0.40	Value of c in inches....0.95
Rainfall in inches............0.35	Value of c in inches....0.90
Rainfall in inches............0.30	Value of c in inches....0.85
Rainfall in inches............0.25	Value of c in inches....0.80
Rainfall in inches............0.20	Value of c in inches....0.75
Rainfall in inches............0.15	Value of c in inches....0.70
Rainfall in inches............0.10	Value of c in inches....0.65

The Craig Formula.[1]

$$Q = 440 \times B \times N \text{ hyp. log} \frac{8\,L^2}{B}$$

where $Q =$ the total discharge in cubic feet per second.

$N = c\ v\ i$, where $v =$ the velocity towards the culvert in feet per second.

$i =$ the number of inches of rainfall.

$c =$ the coefficient of discharge.

$L =$ the extreme length of the drainage area.

$D =$ the mean width of the drainage area.

The McMath Formula.[1]

$$Q = c\,v\,\sqrt[5]{S\,A^4} = A\,c\,v\,\sqrt[5]{s/A}$$

where $c =$ the proportion of rainfall that reaches sewers.

$v =$ the number of cubic feet of water falling upon an acre of surface per second during the period of greatest intensity of rain. It is practically the same as the rate in inches per hour.

$s =$ the mean surface grade in feet per thousand.

$A =$ the area drained in acres.

$Q =$ the discharge in cubic feet per second.

This formula was derived with especial reference to St. Louis conditions.

The Chamier Formula.[2]

$$Q = 640 \times R \times C \times M^{3/4}$$

where $Q =$ the discharge in cubic feet per second.

$R =$ the average rate of the greatest rainfall anticipated in inches per hour for such duration as will allow the flood water flowing to the outlet from the farthest extremity of the catchment area.

$c =$ a coefficient of surface discharge, giving the proportion of rainfall that may be expected to flow off the surface.

The above formula has been tested by Mr. Chamier on streams in India having drainage areas of from 20 acres to 400 square miles.

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[1] Proceedings Inst. C. E., Vol. 80, p. 211, 1884 to 1885.

[1] Trans. Amer. Soc. C. E., Vol. 16, p. 179, 1886. "Determination of the Size of Sewers," R. E. McMath.

[2] Proceedings Inst. C. E., Vol. 134, p. 313, 1897.

The Cramer Formula.[1]

$$Q = \frac{c_3 R_3 m M (S_2)^{1/3}}{9 + (0.0658 m R_2 M)^{1/3}}$$

where Q = the discharge in cubic feet per second.

R_3 = the mean annual rainfall in inches.

$S_2 = \frac{e_1 + e_2}{l}$ = the mean slope and declivity of the whole basin; e_1 being its average altitude in feet, e_2 being the altitude of the point of discharge, and l being the average distance in feet traveled by the water from the boundaries of the watershed to the point of measurement.

c_3 = a variable coefficient.

= 186 for rough natural basins of rivers.

= 697 for smooth, comparatively level and impervious areas like well-built cities.

m, depends on the total area M, the flat area F, which is likely to be inundated in freshets, and the mean annual rainfall R_3, such relation being expressed by:

$m = 1 - \sin\left(-\tan^{-1}\frac{709 F}{M R_3}\right)$ for the simple case when F is distributed in an approximately uniform manner throughout the whole basin, whereas if F is concentrated only at the lower end of the basin we must place

$$m = 1 - \sin\left(-\tan^{-1}\frac{1418 F}{M R_3}\right)$$

The Italian Formulas.[1]

$$Q = \frac{1819 M}{0.311 + \sqrt{M}} \quad (1)$$

$$Q = \frac{2600 M}{0.311 + \sqrt{M}} \quad (2)$$

The notation in these formulas is the same as that of the Fanning formula. No. 1 is applicable to streams in northern Italy, and No. 2 to small brooks in the same region.

The Kuichling Formulas.[2]

$$q = \frac{44{,}000}{M + 170} + 20 \quad (1)$$

$$q = \frac{127{,}000}{M + 370} + 7.4 \quad (2)$$

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[1] Rheinhard's "Kalendar für Wasserbau Ingenieure," Weisbaden, 1898. N. Y. Assn. Doc., 124th Session, 1901, Vol. 23, No. 70, pt. 1, pp. 614-964.

[1] Zeitsch. Oester. Ing. & Arch. Verein, 1900.

[2] N. Y. Assn. Doc., 124th Sess., 1901, Vol. 23, No. 70, pt. 1, pp. 641-964.

Here $q =$ the discharge in second feet per square mile, and $M =$ the drainage area in square miles. These equations were derived from conditions similar to those in the valley of the Mohawk River. They were obtained from a great amount of flood data on both American and European streams. Equation No. 1 gives the discharge during floods which may occur occasionally. Equation No. 2 gives the discharge during floods that occur but rarely.

The Murphy Formula.[1]

$$q = \frac{46{,}790}{M + 320} + 15$$

The notation here is the same as that of the Kuichling formulas. This equation was derived from a large amount of flood data on streams of the northeastern United States which Mr. Murphy had collected.

The Gray Formula.

$$Q = 5.89\,A^{3/4}$$

where $Q =$ the discharge in second feet per acre, and
$A =$ the drainage area in square miles.

SUMMARY OF EXPONENTS.

The following interesting summary of the exponents used in certain of the preceding formulas was presented in the Proceedings of the American Railway Engineering and Maintenance of Way Association, p. 976:

Formula.	Exponent.
Peck Formula (former Mo. Pac. Ry. practice)	1
Fanning	5/6
McMath	4/5
Hawksley; Burkli-Ziegler; Chamier; Talbot	¾
Tidewater (Virginia) Railway	7/10
Churchill-Wentworth; Cooley	2/3
Myers; O'Connell	½
Dun's data from	1 to ½

In his discussion of logarithmic diagram of the Dun data, Prof. W. D. Pence* found that by drawing tangents to the curve at various points the exponents of the equations of these tangents varied from unity for very small areas to one-half for the largest areas drained. This is a very interesting discovery, and it may be that it represents the law for which engineers have been continually looking, but without further verification of the Dun figures it is impossible to draw any final conclusion in regard to the matter. It would be necessary also to investigate the effect of the various constants in the formulas on the exponents, which is not taken into account by the above table.

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[1] U. S. Geol. Surv. Water Supply Paper, No. 147, p. 189, 1905.

*Proceedings A. R. E. & M. W. Assn., Vol. 10 (1909), pp. 975, 876, 1011-1013.

COMPARISON OF FORMULAS.

Upon completing the library search which resulted in the foregoing compilation of waterway and run-off formulas, a general discussion and comparison of the material thus brought together was undertaken. It appeared to the investigators that something of value might be expected to result from a general study of run-off data with reference to the Dun culvert data gathered in the course of many years' observation on the Santa Fe System; and the remaining time available for the inquiry was devoted to this end. This special investigation took the form of a further library search to gather the actual run-off data for representative streams throughout the country. Had there been available complete figures showing the actual observed velocities, the waterway cross-sectional areas at flood stage could be at once determined for direct comparison with the Dun values for like watershed areas. In the absence of published data as to the velocities, it was decided to reverse the process by determining the hypothetical velocities shown in the final columns of the accompanying tables* of run-off data, designated "hypothetical velocity in feet per second." These velocities were calculated by first determining the "waterway required by Dun's table in square feet" for a corresponding watershed area. An examination of these hypothetical or tentative results, as should be expected, reveals numerous inconsistencies, but there is enough of interest in the compilation as a sidelight on the subject to justify a critical study of the figures. It is also hoped that these results may be of some value later on, should it be deemed expedient to carry on further studies in the direction of working out a general basis for dimensioning culvert areas.

In any event, quite aside from the purely tentative comparisons above referred to, it is believed that railway engineers engaged in litigation on waterway cases may find these extensive compilations, covering the run-off data in some 447 cases, of considerable interest. It should be further explained that the data included in these tables relate to the most reliable available records that could be found for the designated points on the given streams. The drainage area given is that above the respective points of measurement. The discharge in second feet per square mile usually represents the mean flow for the day when the discharge was a maximum, and it is believed that in most cases this is not much below the actual maximum flow. Where a period of record is given, the records of the measurements made throughout that time have been examined, and it is believed that the flood mentioned is the maximum occurring during that period.

THE PERMISSIBLE VELOCITY.

In order to judge even roughly as to the consistency of the hypothetical velocity values above referred to, and also for the purpose of discussing the relationships of the two general types of waterway and run-off formulas in general use, it became necessary to extend the investigation to cover the matter of current practice as to "permissible velocity of water passing

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*Owing to the great extent of these tables, their publication is deferred to the annual **Proceedings.**

through culverts." It appears to be a general opinion that a velocity of 10 ft. per second is not too great to be allowed at the infrequent intervals at which the culvert would be called upon to pass its maximum discharge. Some idea of the range of opinion concerning this matter may be gained from the opinions quoted below.

From Journal Western Society of Engineers, Vol. II.

James Dun (p. 147).

. . . "I have estimated by my tables, in which I assume that the velocity under bridges in flood times would be an average of 10 feet per second."

O. P. Chamberlain (p. 175).

"A velocity of discharge of 10 feet per second is commonly used. As this velocity is much higher than the actual veloctiy in natural watercourses in flat and rolling countries, it is clear that culverts and arches so designed are smaller and more economical than they would be were they designed in accordance with the suggestions of Messrs. Murphy and Alvord."

Prof. A. N. Talbot (p. 185).

"Generally, however, a wise choice of channel site and a little work in changing the channel above and below the opening will make a higher velocity available than the average velocity of the stream. The velocity used in the discussions is 10 feet per second. For the larger openings in flat prairie country it is doubtful whether a velocity of 10 feet per second may usually be obtained, but in broken and hilly country, the stream velocity during flood seasons may considerably exceed this amount. . . . For these smaller waterways, liable to become obstructed, a velocity of 10 feet per second may be obtained, even when a slower velocity, like 5 feet per second, exists in the stream above, by permitting the water to head up 1.5 to 2 feet at the entrance to the culvert. In the formula proposed by the writer a smaller velocity than 10 feet per second was used."

E. Duryea, Jr. (p. 181).

"Neither of these velocities (3.34 feet per second and 17.1 feet per second) is inconsistent with flood conditions or beyond the limits met within actual measurements by the writer."

G. H. Bremner (p. 187).

"Instead of using a velocity of discharge of 10 feet per second, the maximum discharge which we have figured on has been in some cases 9 feet, but usually 8 feet or less for small openings." (C., B. & Q. practice.)

E. C. Murphy (p. 157).

Mr. Murphy states that velocities of from 0.6 feet per second to 21.5 per second cover all cases of flood flow of ordinary streams.

Proceedings American Ry. Eng. and Maint. of Way Assn. (Vol. 10, 1909).

J. A. Atwood, Chief Engineer P. & L. E. Ry. (p. 980), uses 6 feet per second as a maximum velocity for culvert running full.

T. E. Calvert, Chief Engineer C., B. & Q. Ry. (p. 985), gives 10 feet per second veloctiy, which he evidently considers lower than the allowable in firm soils.

J. L. Campbell, Chief Engineer El Paso & Southwestern Railway (p. 987), says:

"Under ordinary conditions, we assume velocities of from 7 to 10 ft. per second for floods, and the velocity in the culverts from 25 to 50 per cent. in excess of that in the channel above or below."

C. H. Fake, Ch. Engr. Miss. Riv. & Bonne Terre Ry. (p. 995), gives 7 ft. per second as the maximum velocity to be allowed.

J. B. Jenkins, Ass't Engr. B. & O. R. R. (p. 998), says: "Calculate area of opening required to carry water at 6 ft. per second.

Prof. W. D. Pence (p. 1013), quotes the following table of "greatest velocities of the current close to the bed consistent with the stability of various materials," as observed by Du Buat, as a "basis for determining the use of paving cross-walls, and other protective measures in culvert construction."

Material in Stream Bed.	Bottom Velocity.
1. Soft clay	0.25 ft. per second.
2. Fine sand	0.50 " " "
3. Coarse sand, and gravel as large as peas	0.70 " " "
4. Gravel as large as French beans	1.00 " " "
5. Gravel 1 in. in diameter	2.25 " " "
6. Pebbles 1½ in. diameter	3.33 " " "
7. Heavy shingle	4.00 " " "
8. Soft rock, brick, earthenware	4.50 " " "
9. Rock, various kinds	6.00 " " "

He also quotes the following table of velocities which should not be exceeded in channels, from the "Ingenieurs Taschenbuch:"

	Velocity, ft. per second		
Materials.	Surface.	Mean.	Bottom.
1. Slimy earth	0.49	0.36	0.26
2. Clay	0.98	0.75	0.52
3. Firm sand	1.97	1.51	1.02
4. Pebbly bed	4.00	3.15	2.30
5. Boulder bed	5.00	4.03	3.08
6. Conglomerate of slaty fragments	7.28	6.10	4.90
7. Stratified rocks	8.00	7.45	6.00
8. Hard rocks	14.00	12.15	10.36

Proceedings Engineers' Club, Philadelphia, Vol. I.

Rudolph Hering (p. 199) gives 11 ft. per second as the actual observed velocity through a certain culvert that he has had under observation.

Charles G. Darrach evidently considers from 4 to 8 ft. per second velocities as within the allowable limits.

Proceedings American Railway Bridge & Building Association, 1897.

A. J. Kelley (p. 94) of the K. C. B. Ry. mentions a case where he found the actual velocity through a culvert as measured by floats was only 1.9 ft. per second during a flood.

Proceedings Institute of Civil Engineers.

George Chamier (Vol. 134, p. 313), says:

"Where a culvert or conduit is subject to a constant discharge, as in the case of underground sewers, it is advisable to provide a slow and steady flow, to avoid erosion of the material, or scouring away of foundations. Under such circumstances the velocity of the stream is generally limited to about 5 ft. per second. But the case is different for short waterways that may not have to discharge a flood once in many years, and then only for a few hours. Mountain streams and flooded rivers often approach the openings with velocities of 10 ft. to 12 ft. per second and even greater, and all waterways should be suitable for carrying any stream at its highest velocity. There is no reason why flood openings, on such rare occasions, should not be taxed to their utmost safe carrying capacity, or that culverts should not be allowed to discharge under moderate pressure. Care must be exercised, in all cases, to secure the foundations of structures from the action of scour; but apart from this, a velocity of 10 ft. per second may generally be safely allowed."

Colonel Hutchinson (Vol. 80, p. 203), Ch. Engr. of Oudh, is said to have assumed a maximum possible velocity of 5 ft. per second through the waterways in his "Waterways of Sye Bridge," Professional Papers on Indian Engineering.

Vol. 80, p. 205. The actual flood velocity under the bridge at Locknow is said to have been 5.4 ft. per second.

Vol. 80, p. 210. At the crossing of the Bombay and Baroda Railway on the Nerbudda river the actual velocity observed at the center of the stream during a heavy flood in August, 1867, was 22 ft. per second, which is probably the surface velocity and equal to a mean velocity of 20 ft. per second, which "is not unlikely to have been the case."

Vol. 27, p. 228. The actual measured velocity in an extraordinary flood is given as 12 ft. per second. For twelve days the stream ran over 10 ft. per second. The mean surface velocity was 10 ft. per second. The velocity of the entire stream was upwards of 9 ft. per second.

P. 219. The observed flood mean velocity in the Gunjal river, India, is given as 9.2 ft. per second, and 12.2 ft. per second. The slopes were 3 ft. per mile.

U. S. Geological Survey Water Supply Papers.

Streams are those of table on "runoff data."

No. 396. Beaver Creek, Chouteau County, Montana, had a velocity during flood of 3 ft. per second.

No. 258. Pacolet river, Pacolet, N. C., had a flood velocity of 5.78 ft. per second.

No. 281. Allegheny river, Pittsburg, Pa., had a velocity of 7.7 ft. per second in a flood of 1898.

No. 216. Susquehanna river, McCalls Ferry, Pa., had a maximum mean velocity in the flood of March 8, 1904, of 18 ft. per second. The minimum mean velocity, except in sections adjoining banks, was 10.2 ft. per second.

"CRITICAL POINT" IN DUN CURVE.

An inspection of the logarithmic scale chart of the Dun data, Fig. 1, shows a curious break of slope at a drainage area of about four square miles. The investigation included an attempt to account for this phenomenon. Complete rainfall data relative to maximum storms were compiled for the state of Kansas in the general region where much of the Dun waterway figures were gathered. The data thus collected were platted into diagrams of the customary type, and "intensity-duration" curves for the maximum rainstorms established.

Some tentative calculations were made bearing upon a few selected situations near the head-waters of streams, for which the government contoured maps were available. The results were consistent as far as the work was carried, although the so-called "critical point" was not fully accounted for, due both to lack of time and to indefiniteness of the data at hand. The matter is still under investigation.

OTHER FEATURES.

The thesis investigation also included a discussion of the factors affecting maximum discharge; economic features in dimensioning culvert areas; and legal aspects of the question. These are omitted from the present paper. There were also gathered through correspondence with various chief engineers and others, considerable valuable data bearing on the subject, much of which, however, was received too late to be of assistance.

Appendix B.

DATA ON THE MAXIMUM FLOOD FLOW OF STREAMS IN VARIOUS SECTIONS OF THE UNITED STATES.

RUNOFF DATA—STREAMS OF NORTHEASTERN UNITED STATES

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
1	Androscoggin River	Rumford, Me.	2,220	1869	25.0			55,500	9,276	5.98	U. S. Geol. Survey 20th Ann. Rept.
2	Androscoggin River	Rumford Falls, Me	2,320	Apr. 22, 1895	23.8	93-04	12	55,200	9,477	5.82	U. S. Geol. Survey Water Supply Paper No. 162.
3	Assabet River	Massachusetts	90	1865	14.6			1,414	2,015	0.72	Trans. Amer. Soc. C. E. Vol. 4.
4	Assabet River	Massachusetts	115	1865	19.0			2,182	2,268	0.96	Trans. Amer. Soc. C. E. Vol. 4.
5	Beaver Dam Creek	Altmar, N. Y	20.7		111.0			2,300	985	2.34	U. S. Engrs. Deep Waterways, 1899.
6	Beaver River	Beaver Falls, N. Y	322.0	April, 1869	17.0			5,382	3,743	1.44	Hydrology State of New York, 1905.
7	Black River	Forestport, N. Y	268.0	April, 1869	39.0			10,450	3,400	3.08	U. S. Geol. Survey Water Supply Paper No. 65.
8	Black River	Forestport, N. Y	278.0	1850	32.7			9,080	3,483	2.61	Trans. Amer. Soc. C. E. Vol. 4.
9	Black River	Lyons Falls, N. Y	878.5	April, 1869	46.0			40,400	5,993	6.75	U. S. Geol. Surv. Water Supply Paper No. 65.
10	Black River	Lyons Falls, N. Y	897.0	April, 1869	46.0			41,400	6,070	6.82	U. S. Engrs. Deep Waterways, 1899.
11	Black River	Carthage, N. Y.	1,812.0	April, 1869	21.2			39,529	8,418	4.70	U. S. Engrs. Deep Waterways, 1899.
12	Black River	Carthage, N. Y. (4 mi. below)	1,824.0	April, 1869	21.0			39,009	8,446	4.63	U. S. Geol. Surv. Water Supply Paper No. 65.
13	Black River	Below Black River, N. Y.	1,869.0	April, 1869	21.0			39,137	8,550	4.58	U. S. Geol. Surv. Water Supply Paper No. 65.
14	Black River	Huntingtonville Dam, N. Y	1,889.0	March, 1898	14.8			28,000	8,600	3.25	U. S. Engrs. Deep Waterways, 1899.
15	Black River	Watertown, N. Y	1,892.0	April, 1869	21.0			39,696	8,606	4.61	U. S. Geol. Surv. Water Supply Paper No. 65.
16	Black River	Ontario Paper Mill, N. Y	1,903.0	April, 1869	15.0			28,337	8,631	3.28	U. S. Geol. Surv. Water Supply Paper No. 65.
17	Black River (Affluents)	New York	523.0	April, 1869	36.8			19,230	4,710	4.08	Trans. Amer. Soc. C. E. Vol. 4.
18	Blackstone River	Rhode Island	480.0	1871	8.8			4,220	4,526	0.93	Trans. Amer. Soc. C. E. Vol. 4.
19	Budlong Creek	Utica, N. Y	1.13	Mar. 25, 1904	120.4			136	110	1.24	U. S. Geol. Surv. Water Supply Paper No. 147.
20	Buffalo River	New York	420.0	Mar. 1, 1902	55.0			23,000	4,255	5.40	Hydrology State of New York, 1905.
21	Camden Creek	Camden, N. Y	61.4	June, 1889	24.0			1,470	1,670	0.88	U. S. Engrs. Deep Waterways, 1899.
22	Canada Creek, East	Dolgeville, N. Y	256.0	Dec. 15, 1901	47.4			6,330	3,353	1.89	Hydrology State of New York, 1905.
23	Canada Creek, East	Dolgeville, N. Y	356.0	Aug., 1898	24.7			8,780	3,932	2.23	U. S. Engrs. Deep Waterways, 1899.
24	Canada Creek, West	Motts Dam, N. Y	47.5		34.1			1,620	1,477	1.10	U. S. Engrs. Deep Waterways, 1899.
25	Canada Creek, West	Hinckley, N. Y.	360.0	Aug., 1874	59.0			21,100	3,954	5.34	Hydrology State of New York, 1905.
26	Canada Creek, West	Trenton Falls, N. Y	375.0	Dec. 15, 1901	97.0			36,300	4,035	9.00	Hydrology State of New York, 1905.
27	Canada Creek, West	Newport Dam, N. Y	472.0	Aug. 25, 1898	47.0			22,000	4,019	5.48	Hydrology State of New York, 1905.
28	Canada Creek, West	Middleville, N. Y	518.0	Aug. 25, 1898	24.9			12,920	4,677	2.77	U. S. Engrs. Deep Waterways, 1899.
29	Catskill Creek	Woodstock Dam, N. Y	210.0	Spring, 1901	100.0			21,000	3,042	6.90	Hydrology State of New York, 1905.
30	Cayuta Creek	Waverly, N. Y	149.0	Feb. 28, 1902	15.5			2,390	2,572	0.93	Rept. Engr. State of New York, 1904.
31	Chemung River	Elmira, N. Y.	2,055.0	June, 1889	67.1			138,000	8,936	15.45	Rept. F. Collingswood to City, 1889.
32	Chenango River	Binghamton, N. Y.	1,582.0	March 1-3, 1902	23.5	01-08	8	35,950	8,153	4.40	U. S. Geol. Surv. Water Supply Paper No. 109.

RUNOFF DATA—STREAMS OF NORTHEASTERN UNITED STATES—Continued

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
33	Chicopee River	Massachusetts	706.0		13.7			9,670	5,449	1.78	Tech. Quart. Vol. 4, p. 326.
34	Chittenango Creek	Lake Oneida, N. Y.	307.0		13.0			4,105	3,659	1.12	Hydrology State of New York, 1905.
35	Clove River		0.7		96.0			67	81	0.83	Hydrology State of New York, 1905.
36	Cochituate River	Massachusetts	19.0	1869	17.4			331	945	0.35	Trans. Amer. Soc. C. E. Vol. 4.
37	Coldspring Brook	Massachusetts	6.43	1886	48.4			311	530	0.59	Trans. Amer. Soc. C. E. Vol. 25.
38	Concord River	Lowell, Mass.	361.0		12.32			4,449	3,960	1.12	Jour. Assn. Eng. Soc. Vol. 31.
39	Connecticut River	Holyoke, Mass.	8,660.0	May, 1854	21.10			183,000			Ch. Eng. U. S. Engr. Corps, 1878.
40	Connecticut River	Hartford, Conn.	10,234.0	May, 1854	20.27	1801-1905	105	207,443			U. S. Geol. Surv. Water Supply Paper No. 162.
41	Croton River, S. Br.	New York	7.8	1869	73.9			576	592	0.97	Trans. Amer. Soc. C. E. Vol. 4.
42	Croton River	West Branch, N. Y.	20.5	Jan., 1874	54.4			1,015	981	1.02	E. M. Treman.
43	Croton River	Croton Dam, N. Y.	339.0		74.9			25,376	3,842	6.70	Trans. Amer. Soc. C. E. Vol. 4.
44	Cuyadutta Creek	Johnstown, N. Y.	40.0	1896	72.4			2,896	1,350	2.14	U. S. Engrs. Deep Waterways, 1899.
45	Deer River	Deer River, N. Y.	101.0	Apr., 1869	78.1			7,860	2,128	3.70	U. S. Engrs. Deep Waterways, 1899.
46	Esopus Creek	Rosedale, N. Y.	417.0	Dec. 10, 1878	145.0			60,000	4,318	13.90	Hydrology State of New York, 1905.
47	Farmington River	Connecticut	584.0		41.7			24,370	4,965	4.90	Ch. U. S. Engr. Corps, 1878.
48	Fish Creek	Saratoga Co., N. Y.	236.0	1872	8.3			1,960	3,219	0.61	Trans. Amer. Soc. C. E. Vol. 4.
49	Fish Creek, E. Branch	Point Rock, N. Y.	104.3	Fall, 1897	80.5			8,400	2,103	3.99	U. S. Engrs. Deep Waterways, 1899.
50	Fish Creek, W. Branch	Williamstown, N. Y.	16.2		30.9			500	870	0.58	Hydrology State of New York, 1905.
51	Fish Creek, W. Branch	Williamstown, N. Y.	16.5		34.0			561	877	0.64	Hydrology State of New York, 1905.
52	Fish Creek, W. Branch	West Camden, N. Y.	47.5	Spring, 1884	34.1			1,620	1,477	1.10	Hydrology State of New York, 1905.
53	Fish Creek, W. Branch	Camden, N. Y.	61.4	June, 1889	24.1			1,475	1,670	0.88	Hydrology State of New York, 1905.
54	Fish Creek, W. Branch	Camden, N. Y.	61.5		23.5			1,456	1,671	0.87	Hydrology State of New York, 1905.
55	Fish Creek, W. Branch	Camden, N. Y.	68.8		21.9			1,335	1,766	0.76	Hydrology State of New York, 1905.
56	Fish Creek, W. Branch	McConnellsville, N. Y.	187.0	1884	32.7			6,170	2,876	2.15	Hydrology State of New York, 1905.
57	Fish Creek, W. Branch	Taberg Station, N. Y.	387.0	Mar. 14, 1898	15.2			5,875	4,097	1.44	Hydrology State of New York, 1905.
58	Fish Creek, W. Branch	Fish Creek, N. Y.	533.0	Mar. 15, 1898	14.2			7,597	4,749	1.60	Hydrology State of New York, 1905.
59	Fishkill Creek	Groveville Dam, N. Y.	200.0	Mar. 1, 1902	68.5			13,700	2,970	4.61	Hydrology State of New York, 1905.
60	Flat River	Rhode Island	61.0	Mar., 1843	120.0			738	1,664	0.44	Trans. Amer. Soc. C. E. Vol. 4.
61	Garoga Creek	4 miles above Ft. Plain, N. Y.	80.8	Fall & Spring	15.8			1,275	1,905	0.67	U. S. Engrs. Deep Waterways, 1899.
62	Genessee River	Mount Morris, N. Y.	1,070.0	May 21, 1894	39.2			42,000	6,608	6.35	Hydrology State of New York, 1905.
63	Genessee River	Rochester, N. Y.	2,365.0	Mar. 19, 1865	17.0			40,200	9,540	4.21	U. S. Engrs. Deep Waterways, 1899.
64	Genessee River	Rochester, N. Y.	2,428.0	Mar. 1865	22.0	1785-1903	119	53,400	9,666	5.53	U. S. Geol. Surv. Water Supply Paper No. 162.

RUNOFF DATA—STREAMS OF NORTHEASTERN UNITED STATES—Continued

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
65	Great River	Westfield, Mass.	14.0		71.4			1,000	805	1.24	Rept. H. F. Mills.
66	Great River	Westfield, Mass.	350.0		151.4			52,800	3,900	1.35	Rept. H. F. Mills.
67	Hockanum River	Connecticut	79.0		78.1			6,170	1,814	3.26	Ch. Engr. U. S. Engr. Corps, 1878.
68	Hudson River	Fort Edward Dam, N. Y.	2,800.0	Apr. 23, 1900	15.7			43,900	10,320	4.25	Hydrology State of New York, 1905.
69	Hudson River	Fort Edward, N. Y.	2,825.0	Apr. 1900	15.6			44,100	10,360	4.26	Rept. E. A. Bond, State Engr., 1900.
70	Hudson River	Mechanicsville, N. Y.	4,500.0	Spring, 1869	15.6	69-03	35	70,000	12,825	5.46	U. S. Geol. Surv. Water Supply Paper No. 162.
71	Independence Creek	Crandall's Mill, N. Y.	93.0	Apr., 1869	67.0			6,200	2,047	3.02	Hydrology State of New York, 1905.
72	Kennebec River	Waterville, Me.	4,380.0	Mar. 2, 1896	25.4	93-04	12	111,400	12,666	8.80	U. S. Geol. Surv. Water Supply Paper No. 162.
73	Kennebec River	Waterville, Me.	4,410.0	1896	25.2			111,200	12,746	8.75	U. S. Geol. Surv. Water Supply Paper No. 147.
74	Kinderhook River	East Nassau, N. Y.	120.0	1892	7.3			876	5,935	0.15	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
75	Mad Brook	Sherburne, N. Y.	5.0	Sept. 3 & 4, 1905	262.0			1,310	455	2.88	U. S. Geol. Surv. Water Supply Paper No. 162.
76	Mad River	Camden, N. Y.	47.0		20.0			922	1,465	0.63	Hydrology State of New York, 1905.
77	Mad River	Camden, N. Y., 1 mile lower	48.0		22.0			1,030	1,480	0.70	Hydrology State of New York, 1905.
78	Merrimac River	Lowell, Mass.	4,085.0		19.83			81,000	12,263	6.60	Jour. Assn. Eng. Soc. Vol. 31, p. 157.
79	Merrimac River	Massachusetts	4,126.0	1852	21.6			89,000	12,310	7.22	Trans. Amer. Soc. C. E. Vol. 4.
80	Merrimac River	Lawrence, Mass.	4,136.0	1852	23.4			96,600	12,311	7.50	Tech. Quart. Vol. 4, p. 326.
81	Merrimac River	Lawrence, Mass.	4,551.0		20.0			91,020	12,894	7.08	Mr. Richard A. Hale.
82	Merrimac River	Lawrence, Mass.	4,553.0	Mar., 1896	18.0	46-04	59	82,000	12,897	6.89	U. S. Geol. Surv. Water Supply Paper No. 162.
83	Merrimac River	Lawrence, Mass.	4,599.0		20.87			96,000	12,957	7.41	Jour. Assn. Eng. Soc. Vol. 31.
84	Mill Brook	Akerman Dam, N. Y.	9.4	Sept. 3 & 4, 1905	241.0			2,264	656	3.46	U. S. Geol. Surv. Water Supply Paper No. 162.
85	Mill River	Massachusetts	58.0	Feb.	15.5			898	1,622	0.55	Tech. Quart. Vol. 4, p. 326.
86	Mohawk River	Ridge Mills, N. Y.	153.0		46.4			7,100	2,606	2.73	U. S. Engrs. Deep Waterways, 1899.
87	Mohawk River	Rome, N. Y. (State Dam)	158.0	Mar. 26, 1904	27.34			4,320	2,648	1.64	U. S. Geol. Survey Water Supply Paper No. 147.
88	Mohawk River	Utica, N. Y.	500.0	Feb. 26, 1891	34.60			17,300	4,610	3.75	Hydrology State of New York, 1905.
89	Mohawk River	Little Falls, N. Y.	1,306.0	Mar. 2, 1902	21.83			28,600	7,245	3.95	U. S. Geol. Surv. Water Supply Paper No. 147.
90	Mohawk River	Rocky Rift Dam, N. Y.	1,337.0	Mar., 1901	17.0			23,150	7,325	3.18	Hydrology State of New York, 1905.
91	Mohawk River	Rexford Flats, N. Y.	3,385.0	1892	23.1			78,350	11,260	6.86	Hydrology State of New York, 1905.
92	Mohawk River	Dunsbach Ferry, N. Y.	3,440.0	Feb. 16, 1908	17.21	98-08	11	59,200	11,410	5.20	Hydrology State of New York, 1905.
93	Moose River	Ayer's Mill, N. Y.	407.0		31.0			12,644	4,196	3.02	Black River Claims Com. Vol. 1.
94	Nashua River	Massachusetts	84.5	1850	71.04			6,000	1,954	3.07	Trans. Amer. Soc. C. E. Vol. 4.
95	Nashua River	Massachusetts	109.0	1848	104.53			11,400	2,210	5.16	Trans. Amer. Soc. C. E. Vol. 4.
96	Nashua River, S. Branch	Massachusetts	122.0	1870	56.1			6,850	2,333	2.96	Trans. Amer. Soc. C. E. Vol. 4.

NOFF DATA—STREAMS OF NORTHEASTERN UNITED STATES—Continued

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
97	Nine Mile Creek	Stittsville, N. Y.	62.6	Aug., 1898	124.9			7,820	1,685	4.64	U. S. Engrs. Deep Waterways, 1899.
98	Norman's Kill	French Mills, N. Y.	111.0	Feb., 1891	11.0			1,210	2,220	0.54	Hydrology State of New York, 1905.
99	Octoraro River	Rolandsville, N. Y.	217.0	1897	28.3			6,140	3,093	1.99	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
100	Oneida Creek	Kenwood, N. Y.	59.0	1890	41.2			3,930	1,636	2.40	U. S. Engrs. Deep Waterways, 1899.
101	Oriskany Creek	Coleman, N. Y.	141.0	1888	55.8			7,830	2,508	3.12	U. S. Engrs. Deep Waterways, 1899.
102	Oriskany Creek	Oriskany, N. Y.	144.3	Spring, 1896	52.7			8,070	2,534	3.19	U. S. Engrs. Deep Waterways, 1899.
103	Oswegatchie Creek	Black Lake Inlet, N. Y.	900.0		10.0			9,000	6,080	1.48	Hydrology State of New York, 1905.
104	Oswegatchie Creek	Ogdensburg, N. Y.	1,609.0		10.0			15,500	7,981	1.94	Hydrology State of New York, 1905.
105	Oswego River	Fulton, N. Y.	5,002.0		3.9			19,500	13,500	1.44	Hydrology State of New York, 1905.
106	Otter Creek	Casler's Paper Mill, N. Y.	63.0	April, 1869	31.0			1,944	1,692	1.15	Hydrology State of New York, 1905.
107	Park River	Connecticut	76.0		30.4			2,325	1,852	1.26	Tech. Quart. Vol. 4, p. 326.
108	Pawtuxet River	Rhode Island	190.0	1867	56.8			10,800	2,900	3.72	Trans. Amer. Soc. C. E. Vol. 4.
109	Pequonnock River	Bridgeport, Conn	25.0	July 29-30, 1905	157.0			3,920	1,080	3.63	U. S. Geol. Surv. Water Supply Paper No. 162.
110	Raquette River	Pierceville, N. Y.	700.0	May 1, 1900	10.0			7,000	5,420	1.29	Hydrology State of New York, 1905.
111	Reels Creek	Deerfield, N. Y.	4.4	Mar. 26, 1904	48.36			212	417	0.51	U. S. Geol. Surv. Water Supply Paper No. 147.
112	Roundout Creek	Rosendale, N. Y.	365.0	Mar. 1, 1902	38.0			14,000	3,981	3.52	Hydrology State of New York, 1905.
113	Salmon River	Altmar, N. Y.	221.0		27.6			6,100	3,128	1.95	U. S. Engrs. Deep Waterways, 1899.
114	Salmon River (West)	Henderson's Mill, N. Y.	190.5	Summer, 1888	30.0			5,670	2,904	1.95	Hydrology State of New York, 1905.
115	Salmon Falls	New Hampshire	200.0	1862	40.0	(?)		8,000	2,970	2.69	Trans. Amer. Soc. C. E. Vol. 4.
116	Salmon Falls	New Hampshire	230.0	1862	19.9	(?)		4,570	3,180	1.44	Trans. Amer. Soc. C. E. Vol. 4.
117	Sandy Creek	Allendale, N. Y.	68.4	1891	87.7			6,000	1,761	3.40	U. S. Engrs. Deep Waterways, 1899.
118	Sandy Creek, So. Branch	Allendale, N. Y.	68.0	1890 or 1891	88.0			6,000	1,756	3.41	Hydrology State of New York, 1905.
119	Sandy Creek, No. Branch	Adams, N. Y.	110.0	Winter, 1897	67.3			7,400	2,220	3.34	U. S. Engrs. Deep Waterways, 1899.
120	Sanquoit Creek	New York Mills, N. Y.	51.5		53.4			2,745	1,605	1.74	U. S. Engrs. Deep Waterways, 1899.
121	Scantic River	North Branch, Conn.	118.0		51.8			6,110	2,296	2.66	Ch. Engr. U. S. Engr. Corps, 1878.
122	Schroon River	Warrensburg, N. Y.	563.0		15.0			8,000	4,878	1.64	Hydrology State of New York, 1905.
123	Schoharie Creek	Empire State Power Co. Dam	930.0	Mar. 21, 1901	53.0			49,600	6,170	8.05	Hydrology State of New York, 1905.
124	Schoharie Creek	Fort Hunter, N. Y.	947.0	1892	44.0			41,715	6,221	6.73	Hydrology State of New York, 1905.
125	Seneca River	Baldwinsville, N. Y.	3,103.0	1865	6.5			20,200	10,806	1.86	Hydrology State of New York, 1905.
126	Six Mile Creek	Cayuga Inlet, N. Y.	46.0	June 21, 1905	195.2			8,980	1,365	6.68	U. S. Engrs. Deep Waterways, 1899.
127	Skinner Creek	Mannsville, N. Y.	6.4	1891	124.2			795	528	1.50	U. S. Engrs. Deep Waterways, 1899.
128	Skinner Creek	Huntingtonville Dam	1,889.0	Dec. 15, 1901	19.2			37,000	8,600	4.31	Hydrology State of New York, 1905.

RUNOFF DATA—STREAMS OF NORTHEASTERN UNITED STATES—Concluded

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
129	Starch Factory Creek	Utica, N. Y.	3.4	Sept. 3 & 4, 1905	209.0	....	....	710	340	2.06	U. S. Geol. Surv. Water Supply Paper No. 162.
130	Stony Brook	Boston, Mass.	12.7	....	121.0	....	....	1,538	758	2.04	Rept. Stony Brook Flood Com.
131	Sudbury River	Massachusetts	70.0	1874	21.8	....	....	1,525	1,780	0.86	Trans. Amer. Soc. C. E. Vol. 4.
132	Sudbury River	Massachusetts	75.0	Feb. 13, 1886	44.3	....	....	3,320	1,840	1.80	Tech. Quart. Vol. 4, p. 326.
133	Sudbury River	Framingham, Mass.	78.0	1897	41.38	....	....	3,228	1,876	1.75	Ch. Engr. Water Dept. N. Y. City.
134	Sylvan Glen Creek	New Hartford, N. Y.	1.18	Mar. 25, 1904	56.58	....	....	667	118	5.75	U. S. Geol. Surv. Water Supply Paper No. 147.
135	Tonawanda Creek	Tonawanda, N. Y.	610.0	Mar. 30, 1896	18.0	....	....	10,600	5,070	2.09	Hydrology State of New York, 1905.
136	Trout Brook	Centerville, N. Y.	23.0	....	50.6	....	....	1,166	1,038	1.12	U. S. Engrs. Deep Waterways, 1899.
137	Unadilla River	New Berlin, El. & P. Co.'s Dam	204.0	Sept. 3 & 4, 1905	40.0	....	....	8,160	3,000	2.72	U. S. Geol. Surv. Water Supply Paper No. 162.
138	Wallkill River	New Platz, N. Y.	736.0	Aug. 7, 1901	10.0	....	....	7,365	5,557	1.33	Hydrology State of New York, 1905.
139	Wantuppa Lake	Fall River, Mass.	28.5	1875	72.0	....	....	2,050	1,153	1.78	Trans. Amer. Soc. C. E. Vol. 4.
140	Williamstown River	Williamstown, Mass.	16.5	....	34.0	....	....	561	878	0.64	U. S. Engrs. Deep Waterways, 1899.
141	Wood Creek	New York	126.5	Spring, 1895	21.0	....	....	2,630	2,373	1.11	Hydrology State of New York, 1905.
142	Woodhull Reservoir	Herkimer, N. Y.	9.4	1869	77.6	....	....	732	656	1.12	Trans. Amer. Soc. C. E. Vol. 4.
143	Woodhull Creek	Hill Tannery, N. Y.	108.0	April, 1869	37.0	....	....	4,040	2,200	1.83	Hydrology State of New York, 1905.

RUNOFF DATA—STREAMS OF MIDDLE ATLANTIC STATES

144	Antietam Creek	Sharpsburg, Md.	293.0	1897 & 1898	11.18	....	....	3,275	3,573	0.92	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
145	Appomattox River	Mattox, Va.	745.0	May 25, 1901	16.20	01-05	5	12,100	5,591	2.16	U. S. Geol. Surv. Water Supply Paper No. 75.
146	Carson Creek, East	....	41.4	....	10.26	....	....	425	1,374	0.31	Jour. Assn. Eng. Soc. Vol. 31.
147	Carson Creek, West	....	7.0	....	18.34	....	....	128	556	0.23	Jour. Assn. Eng. Soc. Vol. 31.
148	Dan River	South Boston, Va.	2,750.0	Dec. 31, 1901	18.62	00-07	8	51,200	1,232	5.00	U. S. Geol. Surv. Water Supply Paper No. 75.
149	Dan River	Clarksville, Va.	3,749.0	....	8.80	....	....	33,000	11,800	2.80	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
150	Delaware River	Lambertville, N. J.	6,500.0	....	53.80	....	....	350,000	15,140	23.10	Trans. Amer. Soc. C. E. Vol. 10.
151	Delaware River	New Jersey	6,750.0	....	50.00	....	....	337,500	......	......	Trans. Amer. Soc. C. E. Vol. 10.
152	Delaware River	Stockton, N. J.	6,790.0	1841	37.50	....	....	254,500	......	......	N. J. Geol. Surv. 1894, pt. 3.
153	Delaware River	Lambertville, Pa.	6,855.0	Jan. 8, 1841	37.10	1786-1905	120	254,000	......	......	U. S. Geol. Surv. Water Supply Paper No. 162.

RUNOFF DATA—STREAMS OF MIDDLE ATLANTIC STATES—Continued

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
154	Great Egg Harbor	May's Landing	215.8	....	22.00	....	....	4,750	3,084	1.54	Jour. Assn. Eng. Soc. Vol. 31.
155	Greenbrier River	Alderson, W. Va	1,344.0	1897	41.60	....	....	56,000	7,340	7.63	U. S. Geol. Surv. 20th Ann. Rept.
156	Juniata River	Newport, Pa	3,480.0	Mar. 1, 1902	84.00	99-08	10	292,000	11,212	26.00	U. S. Geol. Surv. Water Supply Paper No. 109.
157	Monacacy River	Frederick, Md	665.0	1898	29.80	....	....	19,800	5,287	3.76	U. S. Geol. Surv. 20th Ann. Rept.
158	Musconetcong River	Saxton Falls, N. J	68.0	....	15.90	....	....	1,080	1,756	0.62	N. J. Geol. Surv. 1894, pt. 3.
159	Musconetcong River	Finesville, N. J	155.8	....	12.80	....	....	2,000	2,630	0.76	N. J. Geol. Surv. 1894, pt. 3.
160	Neshaminy Creek	(Below Forks), Pa	139.0	1894	78.30	....	....	10,900	2,492	4.38	Eng. News, May, 1893.
161	North River	Port Republic, Va	804.0	1896	29.80	....	....	23,950	5,807	4.14	U. S. Geol. Surv. 20th Ann. Rept.
162	North River	Glasgow, Va	831.0	1896	44.80	96-05	10	37,300	5,866	6.38	U. S. Geol. Surv. 20th Ann. Rept.
163	Passaic River	Chatham, N. J	100.0	Mar. 18, 1903	28.30	....	....	2,830	2,120	1.34	U. S. Geol. Surv. Water Supply Paper No. 241.
164	Passaic River	Little Falls, N. J	773.0	Oct. 10, 1903	41.10	....	....	31,700	5,698	5.57	U. S. Geol. Surv. Water Supply Paper No. 92.
165	Passaic River	Paterson, N. J	796.9	Sept., 1883	24.20	....	....	19,300	5,788	3.34	L. B. Ward.
166	Passaic River	Dundee, N. J	823.0	Oct. 10, 1903	43.38	78-03	26	35,600	5,841	6.10	U. S. Geol. Surv. Water Supply Paper No. 92.
167	Passaic River	Dundee, N. J	981.0	Dec. 12, 1878	20.23	....	....	19,900	6,323	3.15	Tech. Quart. Vol. 4, p. 326.
168	Patapsco River	Woodstock, Md	251.0	Feb. 26, 1908	43.85	....	....	11,000	3,314	3.32	U. S. Geol. Surv. Water Supply Paper No. 241.
169	Patuxent River	Laurel, Md	137.0	1897	31.20	....	....	4,280	2,471	1.73	U. S. Geol. Surv. 19th Ann. Rept.
170	Paulinskill River	New Jersey	126.0	....	54.00	....	....	6,800	2,369	2.87	N. J. Geol. Surv. 1894, pt. 3.
171	Paulinskill River	Hainesburg, N. J	174.8	....	23.00	....	....	4,020	2,781	1.45	Jour. Assn. Eng. Soc. Vol. 31.
172	Pequannock River	New Jersey	48.0	....	115.00	....	....	5,520	1,480	3.73	N. J. Geol. Surv. 1894, pt. 3.
173	Pequannock River	Pompton, N. J	78.0	Mar., 1902	55.78	....	....	4,350	1,876	2.85	U. S. Geol. Survey Water Supply Paper No. 147
174	Pequannock River	Pompton, N. J	84.0	....	52.70	....	....	4,420	1,948	2.27	Jour. Assn. Eng. Soc. Vol. 31.
175	Pequest River	Allamuchy Pond, N. J	1.7	....	23.50	....	....	40	170	0.24	N. J. Geol. Surv. 1894, pt. 3.
176	Pequest River	Huntsville, N. J	31.4	....	19.30	....	....	605	1,208	0.50	N. J. Geol. Surv. 1894, pt. 3.
177	Pequest River	Tranquility, N. J	34.8	....	18.70	....	....	650	1,269	0.51	N. J. Geol. Surv. 1894, pt. 3.
178	Pequest River	Townsburg, N. J	83.4	....	9.60	....	....	800	1,941	0.41	N. J. Geol. Surv. 1894, pt. 3.
179	Pequest River	Belvidere, N. J	158.0	....	12.50	....	....	1,965	2,648	0.74	N. J. Geol. Surv. 1894, pt. 3.
180	Perkiomen Creek	Frederick, Pa	152.0	Feb. 28, 1902	105.40	....	....	16,050	2,597	6.19	Rept. Phila. Water Board, 1902.
181	Potomac River	Cumberland, Md	920.0	....	19.46	....	....	17,900	6,140	2.92	N. J. Geol. Surv. 1894, pt. 3.
182	Potomac River	Cumberland, Md	1,364.0	Nov., 1877	13.10	....	....	17,900	7,390	2.42	Trans. Amer. Soc. C. E. Vol. 10.
183	Potomac River	Dam No. 5, Md	4,640.0	....	20.00	....	....	92,800	13,015	0.71	N. J. Geol. Surv. 1894, pt. 3.
184	Potomac River	Point of Rocks, Md	9,650.0	June 2, 1889	48.90	89-05	17	47,100	....	....	U. S. Geol. Surv. Water Supply Paper No. 162.
185	Potomac River	Maryland	11,043.0	....	42.60	....	....	47,100	....	....	Eng. News, May 25, 1893.

RUNOFF DATA—STREAMS OF MIDDLE ATLANTIC STATES—Continued

Number of Streams	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
186	Potomac River	Georgetown, D. C.	11,124.0	Spring, 1852	15.73	....	....	175,000	......	......	Trans. Amer. Soc. C. E. Vol. 10.
187	Potomac River	Great Falls, Md.	11,427.0	1889	41.20	....	....	47,100	......	......	U. S. Geol. Surv. 14th Ann. Rept.
188	Potomac River	Great Falls, Md.	11,476.0	....	15.25	....	....	174,600	......	......	Jour. Assn. Eng. Soc. Vol. 31.
189	Potomac River	Chain Bridge, D. C.	11,545.0	1893	17.20	....	....	199,000	......	......	U. S. Geol. Surv. 14th Ann. Rept.
190	Potomac River, No. Branch	Cumberland, Md.	891.0	1897	22.80	....	....	20,350	6,046	3.38	U. S. Geol. Surv. 19th Ann. Rept.
191	Ramapo River	Mahwah, N. J.	118.0	Oct., 1903	105.90	....	....	12,500	2,296	5.45	U. S. Geol. Surv. Water Supply Paper No. 147.
192	Ramapo River	Pompton, N. J.	160.0	1882	66.10	....	....	10,540	2,661	3.96	N. J. Geol. Surv. 1894, pt. 3.
193	Raritan River	Boundbrook, N. J.	806.0	Sept. 24, 1882	64.50	1810-1905	96	52,000	5,811	8.94	U. S. Geol. Surv. Water Supply Paper No. 162.
194	Raritan River	Boundbrook, N. J.	879.0	1882	59.30	....	....	52,000	5,942	8.77	N. J. Geol. Surv. 1894, pt. 3.
195	Rock Creek	Washington, D. C.	77.5	....	126.30	....	....	9,800	1,870	5.24	Tech. Quart. Mass. Inst., 1891.
196	Rockaway Creek	Dover, N. J.	52.2	....	43.00	....	....	2,340	1,541	1.52	Jour. Assn. Eng. Soc. Vol. 31.
197	Rockaway Creek	Boonton, N. J.	118.9	....	40.70	....	....	4,840	2,304	2.10	Jour. Assn. Eng. Soc. Vol. 31.
198	Rockaway Creek	Boonton, N. J.	125.0	Mar. 2, 1902	22.24	....	....	2,790	2,364	1.18	U. S. Geol. Surv. Water Supply Paper No. 147.
199	Sawkill River	(Near mouth), N. J.	35.0	....	228.60	....	....	8,010	1,278	6.26	U. S. Geol. Surv. Water Supply Paper No. 35.
200	Schuylkill River	Fairmont, Pa.	1,915.0	1898	12.20	....	....	23,400	8,654	2.70	U. S. Geol. Surv. 20th Ann. Rept.
201	Shenandoah River	Millville, W. Va.	2,995.0	Jan. 13, 1908	17.80	....	....	53,400	10,632	5.02	U. S. Geol. Surv. Water Supply Paper No. 241.
202	Smartswood Lake	New Jersey	16.0	....	68.00	....	....	1,088	865	1.26	N. J. Geol. Surv. 1894, pt. 3.
203	South Branch	New Jersey	276.0	....	100.00	....	....	27,600	3,470	7.96	N. J. Geol. Surv. 1896, p. 256.
204	South Fork	Croyole, Pa	48.6	....	215.00	....	....	10,450	1,483	7.04	Trans. Amer. Soc. C. E. Vol. 24.
205	South River	Port Republic, Va.	246.0	1896-1897	37.40	....	....	9,200	3,283	2.80	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70
206	Staunton River	Randolph, Va.	3,080.0	Dec. 31, 1901	24.40	00-06	7	75,200	10,770	6.98	U. S. Geol. Surv. Water Supply Paper No. 65.
207	Staunton River	Clarksville, Va.	3,546.0	....	10.30	....	....	36,600	11,511	3.18	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
208	Stony Creek	Johnstown, Pa.	428.0	....	70.00	....	....	29,960	4,291	7.00	J. J. R. Croes.
209	Susquehanna River	Binghamton, N. Y.	2,400.0	Mar. 2, 1902	25.20	01-08	8	60,500	9,605	6.30	U. S. Geol. Surv. Water Supply Paper No. 162.
210	Susquehanna River	Binghamton, N. Y.	4,180.0	Mar. 1-2, 1902	25.90	....	....	108,300	12,400	8.75	U. S. Geol. Surv. Water Supply Paper No. 82.
211	Susquehanna River	Northumberland, Pa.	6,800.0	1889	17.50	....	....	119,000	......	......	Eng. News, Feb. 14, 1891.
212	Susquehanna River	Wilkesbarre, Pa.	9,810.0	Mar. 2, 1902	22.13	99-08	10	217,000	......	......	U. S. Geol. Surv. Water Supply Paper No. 109.
213	Susquehanna River	Danville, Pa.	11,100.0	Mar. 3, 1902	27.45	99-08	10	305,000	......	......	U. S. Geol. Surv. Water Supply Paper No. 109.
214	Susquehanna River	Harrisburg, Pa.	24,030.0	June, 1889	30.60	89-08	20	737,000	......	......	U. S. Geol. Surv. Water Supply Paper No. 162.
215	Susquehanna River	McCalls Ferry, Pa.	26,800.0	Mar. 8, 1904	23.60	02-08	7	632,000	......	......	U. S. Geol. Surv. Water Supply Paper No. 109.
216	Susquehanna, West Br.	Williamsport, Pa.	5,640.0	Mar. 2, 1902	29.20	95-08	14	165,000	14,203	11.60	U. S. Geol. Surv. Water Supply Paper No. 109
217	Swartswood Lake	Swartswood Lake, N. J.	16.0	....	65.80	....	....	1,050	865	1.22	N. J. Geol. Surv. 1894, pt. 3.

RUNOFF DATA—STREAMS OF MIDDLE ATLANTIC STATES—Concluded

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
218	Tohickon Creek	Mount Pleasant, Pa	102.0	1885	112.50	....	....	11,500	2,142	5.36	Rept. Phila. Water Board.
219	Wanaque River	New Jersey	101.0	Sept., 1882	66.10	....	....	6,666	2,130	3.13	N. J. Geol. Surv. 1894, pt. 3.
220	Whippany River	Whippany, N. J	37.0	Oct., 1903	61.62	....	....	2,280	1,305	1.75	U. S. Geol. Surv. Water Supply Paper No. 147.
221	Whippany River	Whippany, N. J	55.9	Mar. 1, 1902	27.00	....	....	1,510	1,593	0.95	U. S. Geol. Surv. Water Supply Paper No. 88.
222	Wissahickon Creek	Philadelphia, Pa	64.6	1898	43.50	....	....	2,810	1,714	1.64	U. S. Geol. Surv. Ann. Rept. No. 20, pt. 4.
223	Youghiogheny River	Confluence, Pa	782.0	Aug. 21, 1888	59.00	74-05	32	46,100	5,732	8.07	U. S. Geol. Surv. Water Supply Paper No. 162.

RUNOFF DATA—STREAMS OF SOUTHEASTERN UNITED STATES

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
224	Alabama River	Selma, Ala	15,400.0	Jan. 19, 1892	9.50	91-08	17	146,000	....	......	U. S. Geol. Surv. Water Supply Paper No. 162.
225	Apalachee River	Buckhead, Ga	440.0	Aug. 25, 1908	17.40	01-08	8	7,660	4,345	1.77	U. S. Geol. Surv. Water Supply Paper No. 242.
226	Black Warrior	Cordova, Ala	1,900.0	Mar. 30, 1902	30.00	00-08	9	57,000	8,625	6.61	U. S. Geol. Surv. Water Supply Paper, No. 83.
227	Black Warrior	Tuscaloosa, Ala	4,900.0	Apr. 18, 1900	32.00	89-05	17	157,000	13,365	11.75	U. S. Geol. Surv. Water Supply Paper No. 162.
228	Broad River	Carlton, Ga	762.0	Aug. 25, 1908	62.00	97-08	12	47,300	5,656	8.36	U. S. Geol. Surv. Water Supply Paper No. 242.
229	Broad River	Gaffney, S. C.	1,435.0	....	13.05	....	....	18,710	7,526	2.50	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
230	Broad River	Alston, S. C	4,609.0	May 23, 1901	28.44	....	....	131,000	12,972	10.10	U. S. Geol. Surv. Water Supply Paper No. 75.
231	Cahaba River	Centerville, Ala	1,040.0	Sept. 30, 1906	16.41	02-07	6	17,100	6,510	2.62	U. S. Geol. Surv. Water Supply Paper No. 204.
232	Cape Fear River	Fayetteville, N. C	3,860.0	May 24, 1901	23.00	89-03	15	88,800	11,960	7.43	U. S. Geol. Surv. Water Supply Paper No. 162.
233	Cape Fear River	Fayetteville, W Va	4,493.0	....	1.17	....	....	5,260	12,815	0.41	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
234	Catawba River	Catawba, N. C	1,535.0	May 29, 1901	53.10	....	....	81,500	7,807	10.45	U. S. Geol. Surv. Water Supply Paper No. 75.
235	Catawba River	Rock Hill, S. C	2,987.0	....	21.96	....	....	65,600	10,620	6.17	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
236	Chattahoochee River	Oakdale, Ga	1,560.0	Dec. 30, 1901	31.30	95-04	9	48,800	7,866	6.22	U. S. Geol. Surv. Water Supply Paper No. 197.
237	Chattahoochee River	West Point, Ga	3,300.0	Dec. 30, 1901	26.90	96-08	13	88,800	11,123	7.96	U. S. Geol. Surv. Water Supply Paper No. 197.
238	Coosa River	Rome, Ga	4,001.0	Dec. 31, 1901	16.04	97-03	7	64,160	12,160	5.28	U. S. Geol. Surv. Water Supply Paper No. 75.
239	Coosa River	Riverside, Ala	7,060.0	Mar. 20, 1906	10.72	97-08	12	76,000	....	......	U. S. Geol. Surv. Water Supply Paper No. 204.
240	Coosa River	Riverside, Ala	6,850.0	Oct. 8, 1898	10.53	97-03	7	72,200	....	......	U. S. Geol. Surv. 20th Ann. Rept.
241	Coosawattee River	Carters, Ga	531.0	Nov. 19, 1906	33.40	96-08	13	17,700	4,743	3.74	U. S. Geol. Surv. Water Supply Paper No. 197.
242	Etowah River	Canton, Ga	604.0	Jan., 1895	31.50	95-04	10	19,000	5,046	3.77	U. S. Geol. Surv. 18th Ann. Rept.
243	Etowah River	Rome, Ga	1,800.0	Mar. 20, 1906	33.00	04-08	5	59,500	8,390	7.10	U. S. Geol. Surv. Water Supply Paper No. 202.
244	Flint River	Moline, Ga	892.0	....	7.37	....	....	6,560	5,966	1.10	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
245	Flint River	Woodbury, Ga	988.0	Feb. 28-31, 1902	30.60	00-08	9	30,200	6,344	4.78	U. S. Geol. Surv. Water Supply Paper No. 197.
246	Flint River	Albany, Ga	5,000.0	May 3, 1908	8.52	02-08	7	42,600	13,500	3.16	U. S. Geol. Surv. Water Supply Paper No. 197.

RUNOFF DATA—STREAMS OF SOUTHEASTERN UNITED STATES—Concluded

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
247	French Broad River	Asheville, N. C.	987.0	....	7.88	....	....	7,760	6,340	1.22	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
248	Hiwassee River	Murphy, N. C	410.0	Mar. 19, 1899	54.50	97-05	9	22,300	4,209	5.30	U. S. Geol. Surv. Water Supply Paper No. 197.
249	James River	Buchanan, Va.	2,058.0	Feb. 16, 1908	30.10	96-08	13	62,000	8,942	6.95	U. S. Geol. Surv. Water Supply Paper No. 242.
250	James River	Cartersville, Va.	6,230.0	Oct. 21, 1906	13.60	99-08	10	84,600	14,852	5.70	U. S. Geol. Surv. Water Supply Paper No. 203.
251	Neuse River	Selma, N. C.	1,175.0	....	6.70	....	....	7,860	6,896	1.14	N. Y. Assn. Doc. 124th Sess. 1901, vol. 23, No. 70.
252	New River	Fayette, W. Va.	6,200.0	Mar. 4, 1899	17.83	....	....	110,500	14,848	7.44	U. S. Geol. Surv. 22d Ann. Rept.
253	Ocmulgee River	Macon, Ga.	2,425.0	Mar. 1, 1902	20.97	93-08	16	50,900	9,651	5.26	U. S. Geol. Surv. Water Supply Paper No. 83.
254	Oconee River	Carey, Ga.	1,346.0	....	7.44	....	....	10,000	7,345	1.36	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
255	Oconee River	Dublin, Ga.	4,182.0	Feb. 12, 1903	8.35	98-08	11	34,900	12,402	2.81	U. S. Geol. Surv. Water Supply Paper No. 197.
256	Oostanaula River	Resaca, Ga.	1,614.0	Dec. 31, 1901	13.75	96-08	13	22,250	7,993	2.79	U. S. Geol. Surv. Water Supply Paper No. 197.
257	Pacolet River	Pacolet, N. C.	400.0	June 6, 1903	88.90	....	....	35,560	4,165	8.54	U. S. Geol. Surv. Water Supply Paper No. 96.
258	Pearl River	Jackson, Miss.	3,120.0	Mar. 31, 1902	12.41	02-08	7	38,800	10,833	3.59	U. S. Geol. Surv. Water Supply Paper No. 83.
259	Roanoke River	Roanoke, Va.	388.0	Aug. 8, 1901	47.70	97-08	12	18,520	4,100	4.51	U. S. Geol. Surv. Water Supply Paper No. 75.
260	Roanoke River	Neal, N. C.	8,717.0	....	7.38	....	....	65,800	....	....	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
261	Saluda River	Waterloo, S. C.	1,056.0	June 8, 1903	18.00	....	....	19,000	6,562	2.90	U. S. Geol. Surv. Water Supply Paper No. 98.
262	Savannah River	Calhoun Falls, S. C.	2,712.0	Apr. 6, 1897	27.80	96-08	13	75,400	10,166	7.43	Ga. Geol. Surv. Bull. No. 16.
263	Savannah River	Woodlawn, S. C.	6,600.0	Aug., 1908	30.30	05-08	4	200,000	....	....	Ga. Geol. Surv. Bull. No. 16.
264	Savannah River	Augusta, Ga.	7,294.0	Sept., 1888	42.50	....	....	310,000	....	....	U. S. Geol. Surv. 14th Ann. Rept.
265	Savannah River	Augusta, Ga.	7,500.0	Sept. 11, 1888	40.00	40-06	....	300,000	....	....	U. S. Geol. Surv. Water Supply Paper No. 162.
266	Tallapoosa River	Sturdevant, Ala.	2,500.0	Mar. 20, 1906	23.65	00-08	9	59,200	9,788	6.05	U. S. Geol. Surv. Water Supply Paper No. 204.
267	Tallapoosa River	Milstead, Ala.	3,840.0	Dec. 30, 1901	18.23	97-03	7	70,000	11,930	5.87	U. S. Geol. Surv. Water Supply Paper No. 75.
268	Tallulah River	Tallulah Falls, Ga.	191.0	Aug. 30, 1906	47.10	99-08	8	9,000	2,907	3.09	Ga. Geol. Surv. Bull. No. 16.
269	Tar River	Tarboro, N. C.	2,290.0	....	6.38	....	....	14,600	9,306	1.57	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
270	Tennessee River	Chattanooga, Tenn.	21,382.0	Mar. 11, 1867	34.40	67-04	38	735,000	....	....	U. S. Geol. Surv. Water Supply Paper No. 162.
271	Tennessee River	Chattanooga, Tenn.	21,418.0	Mar., 1890	20.80	90-06	17	446,000	....	....	U. S. Geol. Surv. 20th Ann. Rept.
272	Tennessee, Little	Judson, N. C.	675.0	Dec. 29, 1901	85.24	....	....	57,500	5,325	10.80	U. S. Geol. Surv. Water Supply Paper No. 75.
273	Tombigbee River	Columbus, Miss.	4,440.0	Mar., 1902	11.36	00-08	9	50,500	12,745	3.96	U. S. Geol. Surv. Water Supply Paper No. 107.
274	Tuckasegee River	Bryson, N. C.	662.0	Mar. 19, 1899	58.23	....	....	38,600	5,076	7.62	U. S. Geol. Surv. 21st Ann. Rept.
275	Tugaloo River	Madison, S. C.	593.0	July 1, 1905	36.90	98-08	10	21,850	5,000	4.37	Ga. Geol. Surv. Bull. No. 16.
276	Yadkin River	Salisbury, N. C.	3,399.0	Mar., 1899	31.60	96-08	13	107,500	11,284	9.55	U. S. Geol. Surv. 21st Ann. Rept.
277	Yadkin River	Norwood, N. C.	4,614.0	....	13.70	....	....	63,200	12,979	4.95	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
278	Yazoo River	Mississippi	13,850.0	....	10.00	....	....	138,500	....	....	Proc. Inst. C. E. Vol. 27, p. 215.

RUNOFF DATA—STREAMS OF CENTRAL UNITED STATES

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
279	Allegheny River	Freeport, Pa.	9,220.0	March, 1905	26.70	74-04	31	246,000			U. S. Geol. Surv. Water Supply Paper No. 162.
280	Allegheny River	Pittsburg, Pa.	11,400.0	1898	25.43			291,000			U. S. Geol. Surv. Water Supply Paper No. 36.
281	Arkansas River	Canyon, Colo.	3,060.0	June, 1905	2.20	88-06	18	6,740	10,650	0.63	U. S. Geol. Surv. Water Supply Paper No. 173
282	Arkansas River	Pueblo, Colo.	4,600.0	May 21, 1901	2.40	94-06	12	11,050	12,960	0.85	U. S. Geol. Surv. Water Supply Paper No. 75.
283	Arkansas River	Hutchinson, Kan.	34,000.0	June 7, 1900	0.34	96-05	10	11,560			U. S. Geol. Surv. 22d Ann. Rept.
284	Arkansas & White Rivers		189,000.0		0.80			151,200			Physics & Hydraulics Miss. River, by Abbot.
285	Belle Fourche River	Belle Fourche, S. D.	3,250.0	June, 1904	1.81			5,980	11,042	0.54	U. S. Geol. Surv. Water Supply Paper No. 147.
286	Blue River	Manhattan, Kan.	9,490.0	May 31, 1903	9.10	95-05	10	86,400			U. S. Geol. Surv. Water Supply Paper No. 96.
287	Cheyenne River	Edgemont, S. D.	7,350.0	July 29, 1905	1.50			11,040			U. S. Geol. Surv. Water Supply Paper No. 162.
288	Chippewa River*	Eau Claire, Wis.	6,740.0	June 8, 1905	9.00	02-07	6	60,600			Wis. Geol. Surv. Bul. No. 20.
289	Crow Wing River	Minnesota	3,576.0		2.84			10,140	11,554	0.88	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
290	Des Plaines River	Riverside, Ill.	630.0	June, 1892	19.10	86-98	12	12,050	5,150	2.34	U. S. Geol. Surv. 20th Ann. Rept.
291	Elkhorn River	Norfolk, Nebr.	2,470.0	May 30, 1903	3.24		7	8,000	9,733	0.82	U. S. Geol. Surv. Water Supply Paper No. 230.
292	Elkhorn River	(At mouth), Nebr.	5,980.0		1.61			9,650	14,518	0.66	U. S. Geol. Surv. Water Supply Paper No. 230.
293	Fox River	Rapide Croche, Wis.	6,200.0	April, 1906	2.57	95-07	13	15,950	14,768	1.08	Wis. Geol. Surv. Bul. No. 20.
294	Grand River	Lansing, Mich.	1,230.0	Mar. 26, 1904	18.71	01-06	6	23,050	7,040	3.28	U. S. Geol. Surv. Water Supply Paper No. 147.
295	Grand River	Grand Rapids, Mich.	4,900.0	June 9, 1905	10.10	01-06	6	49,500	13,365	3.70	U. S. Geol. Surv. Water Supply Paper No. 162.
296	Illinois River	Peoria, Ill.	15,700.0	Mar. 28, 1904	3.30	90-05	16	51,800			U. S. Geol. Surv. Water Supply Paper No. 162.
297	Kalamazoo River	Ceresco, Mich.	489.0	May 22, 1897	0.97			474	4,560	0.10	U. S. Geol. Surv. Water Supply Paper No. 83.
298	Kalamazoo River	Allegan, Mich.	1,470.0	May 21, 1897	1.72			2,525	7,652	0.33	U. S. Geol. Surv. Water Supply Paper No. 83.
299	Kalamazoo River, No. Branch	Albion, Mich.	138.0	May 9, 1903	1.68			232	2,481	0.09	U. S. Geol. Surv. Water Supply Paper No. 83.
300	Kanawha River	Charleston, W. Va.	8,900.0	Aug. 3, 1875	13.50			120,000			Eng. News, May 25, 1893.
301	Kansas River	Lecompton, Kan.	58,550.0	April, 1897	0.97	91-98	8	47,100			U. S. Geol. Surv. Water Supply Paper No. 147.
302	Kansas River	Lawrence, Kan.	59,841.0	May 31, 1903	3.90	99-05	7	233,000			U. S. Geol. Surv. Water Supply Paper No. 162.
303	Loup River	Columbus, Nebr.	13,540.0	June 6, 1896	5.17	95-05	11	70,000			U. S. Geol. Surv. Water Supply Paper No. 162.
304	Menominee River	Iron Mountain, Mich.	2,415.0	May 17, 1907	6.49	02-07	6	15,700	9,632	1.63	Wis. Geol. Surv. Bul. No. 20.
305	Meramec River	Eureka, Mo.	3,497.0	Sept. 20, 1905	14.63			51,200	11,445	0.45	U. S. Geol. Surv. Water Supply Paper No. 162.
306	Middle Loup	St. Paul, Nebr.	6,850.0	June 6, 1896	2.34		8	16,040			U. S. Geol. Surv. 18th Ann. Rept.
307	Mississippi River		7,283.0		1.49			10,850			N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
308	Mississippi River	St. Paul, Minn.	36,085.0	April 29, 1881	3.33	67-04	38	120,200			U. S. Geol. Surv. Water Supply Paper No. 162.

RUNOFF DATA—STREAMS OF CENTRAL UNITED STATES—Concluded

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
309	Mississippi River	Columbus, Ky.	930,540.0	June 16-22, 1858	1.59	....	....	1,480,000	....	....	Tech. Quart. Vol. 4, p. 326.
310	Mississippi River	....	1,244,000.0	....	1.20	....	....	1,495,000	....	....	Proc. Inst. C. E. Vol. 27, p. 215.
311	Monongahela River	Lock No. 4, Pa.	5,430.0	July 11, 1888	38.10	86-05	20	19,900	13,535	1.47	U. S. Geol. Surv. Water Supply Paper No. 162.
312	Monongahela River	Pittsburg, Pa.	7,391.0	....	21.65	....	....	160,000	....	....	Proc. Eng. Soc. W Pa., Mar. 15, 1910.
313	Neosho River	Iola, Kan.	3,670.0	July 10, 1904	20.33	95-04	10	74,500	11,688	6.38	U. S. Geol. Surv. Water Supply Paper No. 147.
314	Niobrara River	Valentine, Nebr.	6,070.0	July 18, 1903	1.15	....	9	6,980	14,530	0.48	U. S. Geol. Surv. Water Supply Paper No. 230.
315	North Loup River	St. Paul, Nebr.	4,020.0	June 27, 1899	19.10	....	8	76,800	12,187	6.31	U. S. Geol. Surv. Water Supply Paper No. 230.
316	Ohio River	Wheeling Bar	9,000.0	....	9.70	....	....	87,300	....	....	Proc. Inst. C. E. Vol. 27, p. 215.
317	Ohio River	Pittsburg, Pa.	18,644.0	....	18.77	....	....	349,500	....	....	Proc. Eng. Soc. W. Pa., Mar. 15, 1910.
318	Ohio River	Wheeling, W. Va.	23,800.0	Feb. 7, 1884	20.80	....	....	495,000	....	....	U. S. Geol. Surv. Water Supply Paper No. 162.
319	Ohio River	(At mouth)	214,000.0	....	3.30	....	....	712,000	....	....	Proc. Inst. C. E. Vol. 27, p. 215.
320	Osage River	Ottawa, Kan.	1,237.0	May 30, 1904	29.00	....	....	35,900	7,060	5.09	U. S. Geol. Surv. Water Supply Paper No. 147.
321	Platte River	Columbus, Nebr.	56,900.0	May 15, 1905	0.83	95-06	11	47,200	....	....	U. S. Geol. Surv. Water Supply Paper No. 230.
322	Platte River, North	North Platte, Nebr.	28,500.0	June 1, 1897	0.83	95-06	11	23,600	....	....	U. S. Geol. Surv. Water Supply Paper No. 230.
323	Rapid Creek	Rapid, S. D.	320.0	June 6, 1904	2.85	....	....	912	3,735	0.24	U. S. Geol. Surv. Water Supply Paper No. 147.
324	Red River	Arkansas	97,000.0	....	2.32	....	....	225,000	....	....	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
325	Red River	Belle Fourche, S. D.	1,006.0	June 5, 1904	8.00	....	....	8,048	6,400	1.20	U. S. Geol. Surv. Water Supply Paper No. 147.
326	Republican River	Bostwick, Nebr.	22,300.0	July 4, 1905	1.10	04-06	3	24,520	....	....	U. S. Geol. Surv. Water Supply Paper No. 230.
327	Republican River	Superior, Nebr.	22,347.0	May 29, 1903	....	....	0.63	14,080	....	....	U. S. Geol. Surv. Water Supply Paper No. 96.
328	Republican River	(At mouth), Nebr.	23,350.0	....	1.07	....	....	25,000	....	....	U. S. Geol. Surv. Water Supply Paper No. 230.
329	Republican River	Junction, Kan.	25,837.0	May 30, 1903	2.30	....	....	59,500	....	....	U. S. Geol. Surv. Water Supply Paper No. 96.
330	Republican, So. Fork	Benkelman, Nebr.	5,910.0	June 4, 1895	0.06	....	11	355	13,860	0.02	U. S. Geol. Surv. Water Supply Paper No. 230.
331	Saline River	Salina, Kan.	3,311.0	June 1, 1903	3.40	97-03	6	11,280	11,140	1.01	U. S. Geol. Surv Water Supply Paper No. 96.
332	Scioto River	Columbus, Ohio	1,667.0	....	24.00	....	....	39,950	8,116	4.92	U. S. Geol. Surv. 20th Ann. Rept.
333	Smoky Hill River	Ellsworth, Kan.	7,980.0	July, 1895	2.64	95-05	11	21,070	....	....	U. S. Geol. Surv. Water Supply Paper No. 96.
334	Solomon River	Niles, Kan.	6,815.0	June 1, 1903	1.80	97-03	6	12,250	....	....	U. S. Geol. Surv. Water Supply Paper No. 96.
335	St. Croix River	Minnesota	5,950.0	....	6.00	....	....	35,700	14,480	2.47	N. Y. Assn. Doc. 124th Sess. 1901, Vol. 23, No. 70.
336	Verdigris River	Liberty, Kan.	3,067.0	July 8, 1904	16.43	95-04	10	50,400	10,746	4.68	U. S. Geol. Surv. Water Supply Paper No. 147.
337	Wabash River	Logansport, Ind.	3,163.0	Mar. 27, 1904	18.00	85-04	20	57,000	10,900	5.22	U. S. Geol. Surv. Water Supply Paper No. 147.
338	Wabash River	Shoals (of White River), Ind.	4,900.0	Mar. 30, 1904	16.30	85-04	20	80,000	13,365	5.98	U. S. Geol. Surv. Water Supply Paper No. 147.
339	Wisconsin River	Necedah, Wis.	5,800.0	June 10, 1905	16.10	02-07	6	93,500	14,344	6.52	Wis. Geol. Surv. Bul. No 20.

RUNOFF DATA—STREAMS OF SOUTHWESTERN UNITED STATES

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
340	Canadian River	French, N. Mex.	1,478.0	Oct., 1904	105.56			156,000	7,670	2.04	U. S. Geol. Surv. Water Supply Paper No. 147.
341	Canadian River	Taylor, N. Mex.	2,832.0	Oct., 1904	32.11			90,800	10,370	8.77	U. S. Geol. Surv. Water Sypply Paper No. 147.
342	Canadian River	Logan, N. Mex.	11,440.0	Oct., 1904	12.29			140,500			U. S. Geol. Surv. Water Supply Paper No. 147.
343	Cherry Creek	Colorado	175.0		57.00			9,970	2,783	3.58	U. S. Geol. Surv. Water Supply Paper No. 81.
344	Colorado River	Austin, Texas	37,000.0	April 7, 1900	3.33	96-04	9	1,232,000			U. S. Geol. Surv. Water Supply Paper No. 162.
345	Colorado River	Hardyville, Ariz.	138,600.0	June 20, 1906	0.84			116,100			U. S. Geol. Surv. Water Supply Paper No. 211.
346	Colorado River	Yuma, Cal.	225,049.0	May, 1902	0.26			59,400			U. S. Geol. Surv. Water Supply Paper No. 81.
347	Colorado River	Yuma, Ariz.	241,000.0	May 20, 1905	0.49	94-05	12	118,000			U. S. Geol. Surv. Water Supply Paper No. 162.
348	Gallinas River	Las Vegas, N. Mex.	90.0	Sept. 30, 1904	129.10			11,619			U. S. Geol. Surv. Water Supply Paper No. 147.
349	Gila River	Florence, Ariz.	17,750.0	Feb. 17, 1891	7.50			133,200	2,015	5.77	U. S. Geol. Surv. Water Supply Paper No. 81.
350	Grand River	Palisade, Colo.	8,546.0	June 5, 1905	4.87			41,500			U. S. Geol. Surv. Water Supply Paper No. 162.
351	Gunnison River	Whitewater, Colo.	7,863.0	June 5, 1905	3.57			28,100			U. S. Geol. Surv. Water Supply Paper No. 162.
352	Hondo Reservoir	New Mexico	1,387.0	July 25, 1905	7.40			10,250	7,448	1.38	U. S. Geol. Surv. Water Supply Paper No. 162.
353	Humboldt River	Golconda, Nev.	10,780.0	May, 1897	0.29			3,120			U. S. Geol. Surv. Water Supply Paper No. 162.
354	Mora River	La Cueva, N. Mex.	159.0	Sept. 29, 1904	139.70			22,200	2,665	8.34	U. S. Geol. Surv. Water Supply Paper No. 147.
355	Mora River	Weber, N. Mex.	422.0	Sept. 30, 1904	65.70			27,700	4,262	6.50	U. S. Geol. Surv. Water Supply Paper No. 147.
356	Pecos River	San Rosa, N. Mex.	2,649.0	Sept. 30, 1904	17.56			46,500	10,120	4.58	U. S. Geol. Surv. Water Supply Paper No. 147.
357	Pecos River	Fort Sumner, N. Mex.	6,191.0	Oct., 1904	7.29			45,100	14,545	3.10	U. S. Geol. Surv. Water Supply Paper No. 147.
358	Pecos River	Roswell, N. Mex.	14,840.0	Oct., 1904	3.75			55,600			U. S. Geol. Surv. Water Supply Paper No. 147.
359	Purgatory River	Trinidad, Colo.	742.0	Sept. 30, 1904	61.20			45,400	5,580	8.15	U. S. Geol. Surv. Water Supply Paper No. 147.
360	Rio Grande River		1,400.0		4.24			59,400	7,480	7.93	Jour. Assn. Eng. Soc. Vol. 31.
361	Rio Grande River	Rio Grande, N. Mex.	11,250.0	Oct., 1904	2.75			30,900			U. S. Geol. Surv. Water Supply Paper No. 147.
362	Rio Grande River	San Marcial, N. Mex.	28,067.0	Oct. 11, 1904	1.17	95-05	11	32,850			U. S. Geol. Surv. Water Supply Paper No. 162.
363	Rio Grande River	El Paso, Texas	30,000.0	June 12, 1905	0.79	89-06 (93-97 missing)	14	23,700			U. S. Geol. Surv. Water Supply Paper No. 162.
364	Salt Creek	(At mouth), N. Mex.	3,052.0	Oct., 1904	4.10			12,500	10,720	1.17	U. S. Geol. Surv. Water Supply Paper No. 147.
365	Salt River	Roosevelt, N. Mex.	5,756.0	Mar., 1893	36.00	88-06		207,500	14,305	14.50	U. S. Geol. Surv. Water Supply Paper No. 73.
366	Salt River	Maricopa Co., Ariz.	12,260.0	Feb., 1891	24.60			295,200			U. S. Geol. Surv. Water Supply Paper No. 81.
367	San Francisco River	Alma, N. Mex.	1,800.0	Feb. 18, 1905	2.82			5,080	8,390	0.61	U. S. Geol. Surv. Water Supply Paper No. 162.
368	Sapello River	Los Alamos, N. Mex.	221.0	Sept., 1904	36.70			8,100	3,122	2.59	U. S. Geol. Surv. Water Supply Paper No. 147.
369	Verda River	McDowell, Ariz.	6,000.0	Mar., 1893	24.10	88-06	19	144,600	14,520	9.96	U. S. Geol. Surv. Water Supply Paper No. 73.

RUNOFF DATA—STREAMS OF CALIFORNIA

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
370	Arroyo Seco (Salinas)	(Above diversion), Cal	218.0		110.23		6	24,000	3,100	7.75	U. S. Geol. Surv. Water Supply Paper No. 81.
371	Cache Creek	Lower Lake, Cal	500.0	Mar. 11, 1904	30.50	01-06	6	15,250	4,610	3.31	U. S. Geol. Surv. Water Supply Paper No. 147.
372	Feather River	Oroville, Cal	3,640.0	Feb., 1904	29.00	02-06	5	105,600	11,645	9.06	U. S. Geol. Surv. Water Supply Paper No. 147.
373	Kern River	Bakersfield, Cal	2,345.0	June 21-22, 1906	4.06	78-06	28	9,520	2,505	3.80	U. S. Geol. Surv. Water Supply Paper No. 213.
374	King River	State Point, Cal	1,742.0	Jan., 1901	25.22			44,000	8,277	5.32	U. S. Geol. Surv. Water Supply Paper No. 81.
375	Merced River	Merced Falls, Cal	1,090.0	May, 1902	5.70			6,210	6,410	0.97	U. S. Geol. Surv. Water Supply Paper No. 81.
376	Mohair River	Victorville, Cal	400.0	Feb., 1901	12.05			4,820	4,165	1.15	U. S. Geol. Surv. Water Supply Paper No. 81.
377	Mokelumne River	Electra, Cal	640.0	1901	20.64	96-01	6	13,220	5,190	2.56	U. S. Geol. Surv. Water Supply Paper No. 81.
378	Mormon Canyon	Los Angeles, Cal	15.5		48.50			737	850	0.86	U. S. Geol. Surv. Water Supply Paper No. 81.
379	Sacramento River	Jellys Ferry, Cal	9,134.0	1896	14.23	96-01	6	130,000			U. S. Geol. Surv. Water Supply Paper No. 81.
380	Sacramento River	Iron Canyon, Cal	9,295.0	Feb., 1904	23.47	01-06	6	218,200			U. S. Geol. Surv. Water Supply Paper No. 147.
381	Sacramento Basin		22,487.0	Feb. 16, 1904	25.58			575,000			U. S. Geol. Surv. Water Supply Paper No. 147.
382	San Antonio River	Jolon, Cal	322.0	1900	47.56	96-01	6	15,300	3,750	4.09	U. S. Geol. Surv. Water Supply Paper No. 81.
383	San Gabriel River	Azusa, Cal	222.0	1901	28.15	96-01	6	6,250	3,128	2.00	U. S. Geol. Surv. Water Supply Paper No. 81.
384	San Joaquin River	Hamptonville, Cal	1,637.0	Jan., 1881	36.51			59,600	8,047	7.43	U. S. Geol. Surv. Water Supply Paper No. 81.
385	San Lorenzo River		235.0	1900	42.00			9,880	3,213	3.07	U. S. Geol. Surv. Water Supply Paper No. 81.
386	Santa Anna River	Warm Spring, Cal	188.0	1900	8.32	96-01	6	1,570	2,870	0.55	U. S. Geol. Surv. Water Supply Paper No. 81.
387	Stanislaus River	Oakdale, Cal	1,051.0	1899	13.26	96-01	6	13,900	6,542	2.13	U. S. Geol. Surv. Water Supply Paper No. 81.
388	Stony Creek	Fresno, Cal	760.0	Mar., 1904	29.21	01-06	6	22,200	5,650	3.94	U. S. Geol. Surv. Water Supply Paper No. 147.
389	Sweetwater River	Sweetwater Dam, Cal	186.0	Jan., 1895	97.50			18,100	2,865	6.32	U. S. Geol. Surv. Water Supply Paper No. 81.
390	Tuolumne River	Lagrange, Cal	1,501.0		30.60			46,000	7,725	5.95	U. S. Geol. Surv. Water Supply Paper No. 81.
391	Tuolumne River	Modesto, Stanislaus Co., Cal	1,635.0	Jan., 1881	14.00			22,900	8,042	2.85	U. S. Geol. Surv. Water Supply Paper No. 81.
392	Yuba River	Bowman Dam, Cal	19.0		316.00			60,200	2,900	20.75	U. S. Geol. Surv. Water Supply Paper No. 81.
393	Yuba River	Smartsville, Cal	1,220.0	Feb., 1904	49.02	03-06	4	59,800	7,014	8.54	U. S. Geol. Surv. Water Supply Paper No. 147.

RUNOFF DATA—STREAMS OF THE NORTH PACIFIC SLOPE OF THE UNITED STATES

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
394	Bear River	Collinston, Utah	6,000.0	May, 1897	1.76	90-04	15	10,560	14,520	0.73	U. S. Geol. Surv. Water Supply Paper No. 162.
395	Beaver Creek	Chouteau County, Mont	45.0	June 6-13, 1906	8.90	....	....	400	1,435	0.28	U. S. Geol. Surv. Water Supply Paper No. 208.
396	Big Blackfoot River	Bonner, Mont	2,465.0	June, 1899	7.00	98-05 (1902 missing)	8	17,250	9,617	1.80	U. S. Geol. Surv. 21st Ann. Rept.
397	Bitterroot River	Missoula, Mont	3,260.0	June, 1899	11.50	98-04 (1902 missing)	7	37,400	11,060	3.39	U. S. Geol. Surv. 21st Ann. Rept.
398	Blackfoot River	Presto, Idaho	1,020.0	Apr. 17-18, 1907	2.30	03-08	6	2,345	6,445	0.36	U. S. Geol. Surv. Water Supply Paper No. 252.
399	Boise River	Boise, Idaho	2,450.0	1896	16.90	95-08	14	41,400	9,696	4.28	U. S. Geol. Surv. 20th Ann. Rept.
400	Cedar River	Ravensdale, Wash	170.0	Nov. 15, 1906	64.50	02-08	7	10,960	2,745	0.40	U. S. Geol. Surv. Water Supply Paper No. 214.
401	Chelan River	Chelan, Wash	950.0	June 17, 1908	10.30	03-08	5	9,770	6,230	1.57	U. S. Geol. Surv. Water Supply Paper No. 252.
402	Clark Fork	Newport, Wash	24,000.0	June 16-19, 1908	6.46	03-08	6	155,000	....	......	U. S. Geol. Surv. Water Supply Paper No. 252.
403	Chalum River	Roslyn, Wash	205.0	Nov. 15, 1906	86.40	03-08	6	17,780	3,006	5.93	U. S. Geol. Surv. Water Supply Paper No. 214.
404	Columbia River	The Dalles, Ore	237,000.0	June, 1894	5.87	79-08	30	1,390,000	....	......	U. S. Geol. Surv. Water Supply Paper No. 252.
405	Fifteen Mile Creek	Chinook, Mont	40.0	June 6-13, 1906	41.00	....	....	1,640	1,350	1.32	U. S. Geol. Surv. Water Supply Paper No. 208.
406	Fogey Creek	Harlem, Mont	25.0	June 6-13, 1906	15.00	....	....	375	1,080	0.35	U. S. Geol. Surv. Water Supply Paper No. 208.
407	Frenchman Creek	Saco, Mont	1,700.0	June 6-13, 1906	4.00	....	....	6,800	8,195	0.83	U. S. Geol. Surv. Water Supply Paper No. 208.
408	Grande Ronde	Hilgard, Ore	660.0	Apr. 14, 1904	6.80	03-08	5	4,480	5,268	0.85	U. S. Geol. Surv. Water Supply Paper No. 135.
409	Grande Ronde	Elgin, Ore	1,350.0	Apr. 15-19, 1904	6.20	03-08	5	8,370	7,355	1.14	U. S. Geol. Surv. Water Supply Paper No. 135.
410	Green River	Blake, Utah	38,200.0	May, 1897	1.76	....	....	67,100	....	......	U. S. Geol. Surv. 19th Ann. Rept.
411	Kachess River	Easton, Wash	63.0	Nov. 16, 1906	36.50	03-08	5	2,300	1,692	1.36	U. S. Geol. Surv. Water Supply Paper No. 214.
412	Le Noir Coulee	Malta, Mont	16.0	June 6-13, 1906	538.00	....	....	5,918	710	8.34	U. S. Geol. Surv. Water Supply Paper No. 208.
413	Malhuer River	Vale, Ore	4,860.0	Feb. 25, 1904	3.00	03-08	6	14,580	13,311	1.09	U. S. Geol. Surv. Water Supply Paper No. 135.
414	Milk River	Havre, Mont	2,500.0	June 6-13, 1906	1.60	....	....	4,000	9,787	0.41	U. S. Geol. Surv. Water Supply Paper No. 208.
415	Milk River	Malta, Mont	9,200.0	June 6-13, 1906	1.20	....	....	11,040	....	......	U. S. Geol. Surv. Water Supply Paper No. 208.
416	Milk River, No. Fork	Chinook, Mont	1,432.0	June 6-13, 1906	5.40	....	....	7,740	7,558	1.02	U. S. Geol. Surv. Water Supply Paper No. 208.
417	Milk River, W. Fork	Chinook, Mont	1,318.0	June 6-13, 1906	2.30	....	....	3,035	7,275	0.42	U. S. Geol. Surv. Water Supply Paper No. 208.
418	Naches River	North Yakima, Wash	1,120.0	Nov. 14, 1906	19.58	98-08	11	21,900	6,756	3.24	U. S. Geol. Surv. Water Supply Paper No. 214.
419	Owyhee River	Owyhee, Ore	9,875.0	Feb. 24, 1904	2.10	03-08	5	20,780	....	......	U. S. Geol. Surv. Water Supply Paper No. 135.
420	Palouse River	Hooper, Wash	2,210.0	Mar. 9, 1904	7.40	03-08	6	16,350	7,260	1.77	U. S. Geol. Surv. Water Supply Paper No. 135.
421	Powder River	Salisbury, Ore	275.0	Apr. 14, 1904	5.80	03-08	5	1,595	3,590	0.44	U. S. Geol. Surv. Water Supply Paper No. 135.

RUNOFF DATA—STREAMS OF THE NORTH PACIFIC SLOPE OF THE UNITED STATES—Concluded

Number of Stream	Stream	Place	Drainage Area in Square Miles	Date	Discharge in Cu. Ft. per Second per Sq. Mile	Period of Record	Years	Total Discharge in Cu. Ft. per Second	Waterway Required by Dun's Table Sq. Ft.	Hypothetical Velocity in Feet per Second	Authority
422	Rock Creek	Hinsdale, Mont	976.0	June 6-13, 1906	18.00	....	....	17,600	6,308	2.78	U. S. Geol. Surv. Water Supply Paper No. 208.
423	Salmon Creek	Malott, Wash	152.0	Apr. 29, 1904	3.80	03-08	6	578	2,597	0.22	U. S. Geol. Surv. Water Supply Paper No. 135.
424	Savoy Creek	Savoy, Mont	93.0	June 6-13, 1906	19.00	....	....	1,770	2,030	0.87	U. S. Geol. Surv. Water Supply Paper No. 208
425	Second Creek	Saco, Mont	25.0	June 6-13, 1906	68.00	....	....	1,700	1,080	1.57	U. S. Geol. Surv. Water Supply Paper No. 208.
426	Snake River	Minidoka, Idaho	22,600.0	1897	2.10	97-08 (1900 missing)	11	47,400	....	......	U. S. Geol. Surv. 20th Ann. Rept.
427	Snake River, No. Fork	Ora, Idaho	1,040.0	May 20, 1904	5.20	03-08	6	5,400	6,510	0.83	U. S. Geol. Surv. Water Supply Paper No. 135.
428	Snake River, So. Fork	Moran, Wyo	820.0	May 26-June 3, 1904	9.70	03-08	5	7,950	5,836	1.36	U. S. Geol. Surv. Water Supply Paper No. 135.
429	Snake River, So. Fork	Lyon, Idaho	5,480.0	May, 25, 1904	9.40	03-08	6	54,800	14,380	3.83	U. S. Geol. Surv. Water Supply Paper No. 135.
430	Spokane River	Spokane, Wash	4,000.0	1897	8.22	97-08	12	32,880	12,160	2.71	U. S. Geol. Surv. 20th Ann. Rept.
431	Teton River	St. Anthony, Idaho	960.0	June 17, 1908	6.10	03-08	6	5,850	6,260	0.93	U. S. Geol. Surv. Water Supply Paper No. 252.
432	Three Mile Creek	Chinook, Mont	26.0	June 6-13, 1906	67.00	....	....	1,740	1,100	1.58	U. S. Geol. Surv. Water Supply Paper No. 208.
433	Tieton River	Naches, Wash	289.0	Nov. 14, 1906	48.80	02-08	7	14,100	3,549	3.98	U. S. Geol. Surv. Water Supply Paper No. 214.
434	Umatilla River	Gibbon, Ore	353.0	Mar. 15, 1908	28.40	00-08	9	10,030	3,910	2.57	U. S. Geol. Surv Water Supply Paper No. 252.
435	Umatilla River	Yoakum, Ore	1,200.0	May 30, 1906	19.90	03-08	6	23,900	6,960	3.44	U. S. Geol. Surv. Water Supply Paper No. 214.
436	Umatilla River	Umatilla, Ore	2,130.0	May 31, 1906	7.10	03-08	5	15,100	9,093	1.67	U. S. Geol. Surv. Water Supply Paper No. 214.
437	Walla Walla River	Milton, Ore	130.0	Mar. 8 and Apr. 14, 1904	16.30	03-08	6	2,120	2,405	0.88	U. S. Geol. Surv. Water Supply Paper No. 135.
438	Walla Walla River, So. Fork	Milton, Ore	72.0	Apr. 14, 1904	23.00	03-08	6	1,656	1,804	0.92	U. S. Geol. Surv. Water Supply Paper No. 135.
439	Wallowa River	Joseph, Ore	47.0	July 3-4, 1904	15.50	03-08	5	730	1,485	0.49	U. S. Geol. Surv. Water Supply Paper No. 135.
440	Wallowa River	Elgin, Ore	870.0	May 30-June 1, 1904	4.70	03-08	5	4,080	5,966	0.68	U. S. Geol. Surv. Water Supply Paper No. 135.
441	Wayne Creek	Harlem, Mont	95.0	June 6-13, 1906	34.00	....	....	3,230	2,065	1.56	U. S. Geol. Surv. Water Supply Paper No. 208.
442	Weiser River	Weiser, Idaho	1,670.0	Mar. 19, 1890	7.79	90,91,95-03	11	13,000	8,124	1.60	U. S. Geol. Surv. 11th Ann. Rept.
443	Willamette River	Albany, Ore	4,860.0	Jan., 1903	38.60	92-08	17	188,000	13,244	1.42	U. S. Geol. Surv. Water Supply Paper No. 252.
444	Yadley Coulee	Malta, Mont	20.0	June 6-13, 1906	138.00	....	....	2,760	970	2.84	U. S. Geol. Surv. Water Supply Paper No. 208.
445	Yakima River	Martin, Wash	56.0	Nov. 16, 1906	110.00	03-08	5	6,160	1,594	3.87	U. S. Geol. Surv. Water Supply Paper No. 214.
446	Yakima River	Yakima, Wash	3,300.0	Nov. 15, 1906	19.40	96-08	13	64,000	11,123	5.75	U. S. Geol. Surv. Water Supply Paper No. 214
447	Yakima River	Kiona, Wash	5,230.0	Nov. 17, 1906	12.10	96-08	13	63,400	13,770	4.61	U. S. Geol. Surv. Water Supply Paper No. 214.

Appendix C.

BIBLIOGRAPHY—AN INDEX TO LITERATURE ON THE SUBJECT OF WATERWAYS FOR CULVERTS AND ALLIED TOPICS.

Association Railway Superintendents Bridges and Buildings, Report 7th Convention, 1897, pp. 555-574.

Abstract of Report, Eng. News, Vol. 38, p. 260.

Alvord, J. W., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, 1909, Vol. 10, p. 979.

Atwood, J. A., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, 1909, Vol. 10, p. 980.

Babb, Cyrus C., Rainfall and River Flow, Trans. Am. Soc. C. E., Vol. 28, p. 323.

Baker, I. O., Capacity of Tile Drains and Open Ditches, Eng. News, 9-4-86.

Beahan, Willard, The Field Practice of Railway Location.

Berg, Walter G., Association Railway Superintendents Bridge and Building. Report 7th Convention, 1897, pp. 555-574.

Beye, J. C., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, 1909, Vol. 10, p. 984.

Brackett, Dexter, Rainfall Received and Collected on the Watershed of the Sudbury River and Cochituate and Mystic Lakes, Jour. Ass'n Eng. Soc., Vol. 5, p. 395.

Bremner, George H., Areas of Waterways for Railroad Culverts and Bridges, Jour. W. Soc. Eng., Vol. 11, pp. 137 and 797.

Bremner, George H., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 980.

Burnie, A. R., On Mean or Average Annual Rainfall and Fluctuation to Which It Is Subject, Proceedings Inst. C. E., Vol. 109, p. 89.

Calvert, T. E., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 985.

Campbell, J. L., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 987.

Chamier, George, Capacities Required for Culverts and Flood Openings, Proceedings Inst. C. E., Vol. 134, p. 213.

Channels, Dimensions of for Surface Discharge (C. E. Livesay), Proceedings Inst. C. E., Vol. 128, p. 283.

Clark, W. J. B., Note on Flood Discharge of Tansa Catchment Area, Proceedings Inst. C. E., Vol. 114, p. 280.

Clark, E. W., Storm Flows from City Areas and Their Calculations, Eng. News, Vol. 48, p. 386.

Cleeman, Discussion of Formulas, Proceedings Engrs. Clubs, Philadelphia, Vol. 1, p. 146.

Cleeman, Railway Engineers' Practice.

Codman, J. E., Rainfall and Stream Flow in Eastern Pennsylvania, Proceedings Engrs. Club, Philadelphia, 1897, p. 179.

Coghlan, T. A., Discharge of Streams with Reference to Rainfall, New South Wales, Proceedings Inst. C. E., Vol. 75, p. 176.

Coghlan, T. A., Discharge of Streams in Relation to Rainfall, Van Nostrands, Eng. Mag., Vol. 31, p. 16.

Craig, James, Maximum Flood Discharge from Catchment Areas with Special Reference to India, Proceedings Inst. C. E., Vol. 80, p. 211.

Culverts, Ry. Gaz., 1885, p. 54; Capacities for and Flood Discharge, Eng. News, Vol. 41, p. 61; Capacities for and Flood Openings (Chamier), Proceedings Inst. C. E., Vol. 134, p. 313; Determining the Size of Railroad, Ry. Gaz., 1902, p. 976; Nichols Hollow, Ill., Soc. Eng. & Surv., Vol. 4, p. 75; C. B. & Q., Iron, Ry. Gaz., Vol. 19, p. 122; Failure of at Schenectady, N. Y., Eng. Rec., Vol. 47, p. 255; Pipe, Ry. Gaz., Vol. 19, p. 47; Proportions, Ry. Gaz., 1886, p. 629; A Railroad, Ill. Soc. Eng. & Surv., 1888, pp. 28 and 328; A Railroad, Ry. Gaz., 1888, p. 329; Railway Legal Decisions, Eng. Rec., Vol. 59, p. 281; Under High Embankments, Eng. News, Vol. 53.

Curd, W. C., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 989.

Davis, G., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 994.

Designs and Construction Arch Culverts, Eng. News, Vol. 48, p. 534; of Arch Culverts, Eng. Rec., Vol. 51, p. 668; of Arch Culverts, Eng. News, 6-13-01, p. 435; of Concrete Arches, Proceedings Ind. Eng. Soc., Vol. 25, p. 107.

Discharge, Theoretical, from a Watershed, Eng. Rec., Vol. 27, p. 311; from Tansa Catchment Basin, Eng. Rec., Vol. 31, p. 380; of Streams with Reference to Rainfall, New South Wales, Proceedings Inst. C. E., Vol. 75, p. 176; of Streams with Reference to Rainfall, Van Nostrands, Vol. 31, p. 16.

Dorr, Edgar S., Diagram for Approximate Sewer Calculations, Jour. Assoc. Eng. Soc., Vol. 10, p. 353.

Douglas, W. J., Design and Construction of a 50-ft. Brick Arch Culvert, Eng. News, Vol. 48, p. 534.

Duryea, Edwin, Tables of Excessive Precipitation at Chicago from 1889 to 1897 (incl.), Jour. W. Soc. Eng., Vol. 4, pp. 73 and 147.

Encyclopedia Britannica, Hydromechanics, 19th Ed., Vol. 12, p. 502.

Enger, Melvin L., The Relation of Waterways to Drainage Areas, Ill. Soc. Eng. & Surv., Vol. 23, p. 66.

Engineering, Civil, Rankine.

Engrs. Club, Philadelphia, Proceedings, Vol. 1, p. 146.

Evans, E. A., Brief Discussion of Conditions Contributing to Freshets in James River Watershed, Monthh. Weather Rev., Vol. 321, p. 67.

Evaporation, Rainfall and Delivery of Streams in Devonshire, Some Statistics Dealing With, Trans. Devon. Ass'n Adv. Science, Vol. 33, p. 500.

Fake, C. H., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 995.

Fanning, G. T., A Treatise on Water Supply Engineering, Proceedings Inst. C. E., Vol. 150, p. 506.

Fisher, S. B., discussion of, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 994.

Fitzgerald, D., Max. Rates of Rainfall, Eng. News, 5-31-84; Rainfall, Flow of Streams and Storage, Trans. Am. Soc. C. E., Vol. 27, p. 253.

Floods and the Means of Their Prevention, Proceedings Engr. Soc. W. Penn., Vol. 23, p. 306; Bibliography of Flood Literature, Report Water Com., N. Y., pp. 567-656; Damage by March Floods on P. C. C. & St. L. Ry., Ry. Gaz., 5-14-97; Discharge from Small Watersheds, Tech. Quarterly, Vol. 4, p. 316; Discharge of Rivers (O'Connell), Proceedings Inst. C. E., Vol. 27, p. 215; Discharge, Eng. Rec., Vol. 39, p. 163; On the Determination of Flood Discharges and of the Backwater Caused by Contractions, Trans. Am. Soc. C. E., Vol. 11, p. 211; Note on Flood Discharge of Tansa Catchment Area, Proceedings Inst. C. E., Vol. 119, p. 280; Index to Flood Literature, U. S. G. S. Water Supply Paper No. 162, p. 88; Maximum Discharges from Catchment Areas with Special Reference to India, Proceedings Inst. C. E., Vol. 80, p. 211.

Floods in River Seine, Eng. Soc. W. Pa., 3-15-10; Monsoon Floods in India, Proceedings Inst. C. E., Vol. 27, p. 219; Prevention of in Stony Brook, Boston City Doc. No. 159, 1886; River Floods and Melting Snow, Month. Weather Rev., Vol. 31, p. 173; Flow of Sudbury River, Mass., 1875 to 1879, Trans. Amer. Soc. C. E., Vol. 10, p. 225.

Folsom, C. W., Railroad Washouts, Jour. Assoc. Eng. Soc., Vol. 5, p. 304.

Folwell, A. P., Sewerage, p. 52.

Formula, Application of Lauterburg's, Proceedings Inst. C. E., Vol. 149, p. 391; For Calculating Flow of Water in Pipes and Channels, Jour. Assoc. Eng. Soc., Vol. 13, p. 295; Run-off for Sewerage Purposes, Eng. Rec., Vol. 37, pp. 75 and 116; Wentworth's, Ry. Gaz., 1903, p. 57.

Forest and Run-off Relations, Eng. Rec., Vol. 58, pp. 310 and 355.

Foss, W. B., New Formula for Calculating Flow of Water in Pipes and Channels, Jour. Assoc. Eng. Soc., Vol. 13, p. 295.

Fox, W., Relation Between Rainfall, Flow Off Ground, Size and Actual Yield of Reservoir. Engineering, Vol. 63, p. 743.

Francis, Herschel & Clemens, Prevention of Floods in Stony Brook, Boston City Doc., No. 159, 1886.

Freshets in James River Watershed, A Discussion of Conditions Contributing to, Month. Weather Rev., Vol. 32, p. 67.

Fteloy, A., Flow of Sudbury River, Mass., 1875-79, Trans. Am. Soc. C. E., Vol. 10, p. 225.

Geology, Elements of (Le Conte), pp. 11, 12 and 18-20.

Gilmore, Gen., Obstructions to River Discharge by Bridge Piers, Eng. News, 6-10-82.

Gregory, C. E., Rainfall and Runoff in Storm Water Sewers, Trans. Am. Soc. C. E., Vol. 58, p. 458.

Grunsky, C. E., Rain and Runoff near San Francisco, Cal., Trans. Am. Soc. C. E., Vol. 61, p. 496.

Hartford, F. B., Some New Sewer Formulas, Jour. Assoc. Eng. Soc., Vol. 4, p. 220.

Hering, R., Formula Introduced, Proceedings Eng. Club, Philadelphia, Vol. 1, p. 146; Report of Sewerage Works in Europe; Rep. Nat. Bd. Health, 1881, p. 119; Sewerage Systems, Trans. Am. Soc. C. E., Vol. 10, p. 361.

Hill, C. D., Notes on Designing Chicago Sewers, Jour. W. Soc. Eng., Vol. 7, p. 425; A Railroad Culvert, Ill. Soc. Eng. & Surv., Jan., 1888, p. 28; A Supplementary Paper on the Nichols Hollow Culvert, Ill. Soc. Eng. & Surv., Vol. 4, p. 75.

Howden, A. C., Monsoon Floods in India, Proceedings Inst. C. E., Vol. 27, p. 219.

Hoxie, Capt. R. L., Excessive Rainfall Considered with Especial Reference to Their Occurrences in Populous Districts, Trans. Am. Soc. C. E., Vol. 25, p. 70.

Hoyt, J. C., Comparison Between Rainfall and Runoff in M. E. U. S., Trans. Am. Soc. C. E., Vol. 59, p. 431.

Hutton, W. B., Determination of Flood Discharge of Rivers and of Backwater Caused by Contractions, Trans. Am. Soc. C. E., Vol. 11, p. 211.

Hydraulic Formulæ, Coefficient in, Jour. W. Soc. Eng., Vol. 1, p. 190.

Hydraulic Manual, L. D. A. Jackson.

Hydromechanics, Encyclopedia Britannica, 19th Ed., Vol. 12, p. 502.

Jackson, L. D. A., Hydraulic Manual.

Jenkins, J. B., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 998.

Johnson, T. H., discussion of, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 998.

Johnson, T. T., Data Pertaining to Rainfall and Stream Flow, Jour. W. Soc. Eng., Vol. 1, p. 297.

Keating, W. T., Coefficients in Hydraulic Formulas, Jour. W. Soc. Eng., Vol. 1, p. 190.

Kent, W. J., On Rainfall Discharged from Catchment Areas, Prk. Inst. C. E., Vol. 119, p. 173.

Knauff, M., Removal of Rainfall from Towns Considered with Reference to Sewering of Berlin, Groundheits Ingeneuir, 1882, p. 539.

Kuichling, E., Design of Arch Culverts, Eng. News, 6-13, 1901; Relation Between Rainfall and Discharge Sewers in Populous Districts, Trans. Am. Soc. C. E., Vol. 20, p. 1; Gagings of Sewer Discharge Contemporaneous with Rainfall, Eng. News, 4-13-89.

Lahmer, J. A., discussion of, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 999.

LeConte, Elements of Geology, pp. 11, 12 and 18-20.

Legal Side of Designing Culverts, Eng. Rec., Vol. 51, p. 68.

Legal Decisions, Central Digest, Vol. 48; Sherlock vs. R. Ry. Co, 17 N. E. Rep. 171; R. Ry. Co. vs. Morris, 35 Ark. 622; B. & O. R. Ry. or Sulphur Springs, Ind., School Dist., 96, Pa. 65; Emery vs. Raleigh & Gaston R. Ry., 102 N. C. 209; Emery vs. Raleigh & Gaston R. Ry., 9 S. E. Rep. 139; Norris vs. Savannah R. Ry. Co., 1 So. Rep. 732; Pittsb., Ft. W. & Chi. R. Ry. vs. Gilleland, 56 Pa. 445.

Livesay, C. E., Dimensions of Channels for Surface Discharge, Proceedings Inst. C. E., Vol. 128, p. 283.

Luton, Daniel B., A Comparison of Bridge Waterways, Proceedings Ind. Eng. Soc., 1909, p. 46; Design of Concrete Arches, Proceedings Ind. Eng. Soc., Vol. 25, p. 107; Design of Arch Culverts, Eng. Rec., Vol. 51, p. 668; The Legal Side of Designing Culverts, Eng. Rec., Vol. 51, p. 68.

McLead, Prof. C. H., Velocities and Discharge by Red Float Methods, Canadian Soc. C. E., Jan. to June, 1876, p. 129.

McMath, R. E., Mean Velocity of Streams Flowing in Natural Channels, Trans. Am. Soc. C. E., Vol. 11, p. 186; Determination of Size of Sewers, Trans. Am. Soc. C. E., Vol. 16, p. 179.

Mixer, Charles A., River Floods and Melting Snow, Monthly Weather Review, Vol. 31, p. 173.

Mordell, C. H., Additive Method for Determining Storm-water Runoff, Eng. News, Vol. 61, p. 265; Eng. Rec., Vol. 59, p. 265.

Murphy, E. C., Index to Flood Literature, U. S. G. S. Water Supply Paper No. 162, p. 68, 1905; Methods of Computing Cross-Section Area of Waterways, U. S. G. S. Water Supply Paper No. 147, p. 182, 1905.

Myers, Major E. T., Recommendation for, Ry. Gaz., 1884, p. 523.

Obstructions to River Discharge by Bridge Piers, Eng. News, 6-10-82.

O'Connell, Col. Peter Pierce Lyons, Flood Discharge of Rivers, Proceedings Inst. C. E., Vol. 27, p. 215.

Ogden, H. N., Sewer Design.

Osgood, J. O., discussion of, Proc. Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1001.

Paret, M. P., discussion of, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1007.

Parkinson, Richard M., Light Railway Construction, p. 127.

Parmley, W. C., Rainfall and Runoff in Relation to Sewerage Problems, Jour. Assoc. Eng. Soc., Vol. 20, p. 204.

Peck, R. M., Formula, Proceedings Assoc. Ry. Supt. B. & B. 7th Annual Convention, 1897.

Pence, W. D., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1010. Waterway for culverts, Proceedings Purdue C. E. Society, 1904.

Peterson, W. H., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1014.

Porter, Dwight, Flood Discharge from Small Watersheds, Tech. Quarterly, Vol. 4, pp. 316-327.

Precipitation of Rain at Chicago from 1889 to 1897 inclusive, tables of excessive, Jour. W. Soc. Eng., Vol. 4, pp. 73 and 147.

Rafter, George W., The Relation of Rainfall to Runoff, U. S. Geol. Survey Water Supply Paper No. 80.

Railroad Gazette, Wellington's Editorial, 1884, p. 523.

Railroad Washouts, Jour. Assoc. Eng. Soc., Vol. 5, p. 304.

Railway Construction, Light (R. M. Parkinson), p. 127.

Railway Engineer's Practice, Cleeman.

Railway Location, Economic Theory of (A. M. Wellington), pp. 781-783.

Railway Location, The Field Practice of (Willard Beahan), p. 110.

Rain and Runoff Near San Francisco, Trans. Am. Soc. C. E., Vol. 61, p. 496.

Rainfall and River Flow, Trans. Am. Soc. C. E., Vol. 28, p. 323.

Rainfall and Discharge of Sewers in Populous Districts, Relation Between, Trans. Am. Soc. C. E., Vol. 28, p. 1.

Rainfall and Total Effluent Water, Relation Between Volume of, Proceedings Inst. C. E., Vol. 150, p. 505.

Rainfall, Evaporation and Discharge, Ratios Between, Proceedings Inst. C. E., Vol. 132, p. 415.

Rainfall, Flow Off Ground, Size and Actual Yield of Reservoirs, Relation Between, Proceedings Inst. C. E., Vol. 150, p. 215.

Rainfall and Runoff of the New England, Atlantic Coast and Southwestern Colorado Streams, Jour. Assoc. Eng. Soc., Vol. 31, p. 131.

Rainfall and Runoff in Northeastern United States, a Comparison Between, Trans. Am. Soc. C. E., Vol. 59, p. 431.

Rainfall and Runoff in Relation to Sewerage Problems, Jour. Assoc. Eng. Soc., Vol. 20, p. 204.

Rainfall to Runoff, Relation of, U. S. G. S. Water Supply Paper No. 80.

Rainfall and Runoff in Storm Water Sewers, Trans. Am. Soc. C. E., Vol. 58, p. 456.

Rainfall and Stream Flow, Data Pertaining to, Jour. W. Soc. Engrs., Vol. 1, p. 297.

Rainfall and Stream Flow in Eastern Pennsylvania, Proceedings Inst. C. E., Vol. 131, p. 406.

Rainfall Discharged from Catchment Areas, Proceedings Inst. C. E., Vol. 119, p. 273.

Rainfall Considered with Especial Reference to Occurrence in Populous Districts, Excessive, Trans. Am. Soc. C. E., Vol. 25, p. 70.

Rainfall, Flow of Streams and Storage, Trans. Am. Soc. C. E., Vol. 27, p. 253.

Rainfall in Relation to Sewers, Proceedings Inst. C. E., Vol. 133, p. 432.

Rainfall, Maximum Rates of, Eng. News, 5-31-84.

Rainfall and Fluctuation to Which It Is Subject, Mean or Average Annual, Proceedings Inst. C. E., Vol. 109, p. 89.

Rainfall, Rates of Maximum, Technograph U. of Ill. No. 6, 1891-92, p. 103.

Rainfall Records, Rate of, Eng. News, 1-21-88.

Rainfall Received and Collected on the Watershed of the Sudbury River and Cochituate and Mystic Lakes, Jour. Assoc. Eng. Soc., Vol. 5, p. 395.

Rainfall, Resulting Water Supply and Gauging of Streams, Discussion on, Trans. Am. Soc. C. E., Vol. 4, p. 297.

Rainwater from Towns Considered with Reference to Sewering of Berlin, Removal of, Proceedings Inst. C. E., Vol. 72, p. 536.

Rankine, Civil Engineering, p. 708.

Ransom, C. L., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1015.

River Buffalo; Total Flow at the Town Dam, King William's Town, Cape of Good Hope, from June, 1880, to March, 1883, Compared with Rainfall, Proceedings Inst. C. E., Vol. 81, p. 241.

River Seine, Proceedings Inst. C. E., Vol. LXXXIV, p. 210.

Roberts, Thomas P., Floods in the River Seine, Eng. Soc. W. Pa., March 15, 1910; Floods and Means of their Prevention, Proceedings Eng. Soc. W. Pa., Vol. 23, p. 306.

Runoff from Several Areas, Eng. Rec., Vol. 57, p. 179.

Schmeer, Louis, The Flow of Water.

Selby, O. E., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1016.

Serviss, John H., To Ascertain the Best Angle for Wing Wall of Bridge Abutment, Ill. Soc. Eng. & Surv., Vol. 11, p. 156.

Sewer Design (W. H. Ogden).

Sewerage (A. P. Folwell), p. 52.

Sewerage Systems, Am. Soc. C. E., Vol. 10, p. 361.

Sewerage Works in Europe, Report on; Rept. Nat. Board of Health, 1881, p. 119.

Sewer Calculations, Diagram for Approximate, Jour. Assoc. Eng. Soc., Vol. 10, p. 353.

Sewer Discharge Contemporaneous with Rainfall, Gagings of, Eng. News, 4-13-89.

Sewer Discharge, Formulas for, Eng. News, Vol. 5, p. 390, 1878.

Sewers, Determination of Size of, Trans. Am. Soc. C. E., Vol. 16, p. 179.

Sewer Formulas, Some New, Jour. Assoc. Eng. Soc., Vol. 4, p. 220.

Sewers, Notes on Designing Chicago, Jour. W. Soc. Engrs., Vol. 7, p. 425.

Sewers, Notes on Storm Water, Eng. Rec., Vol. 38, p. 379.

Sewers, Relative Discharging Capacity of Brick and Pipe, Ill. Soc. Eng. and Surv., Vol. 18, p. 63.

Sewers Adopted by City of Washington, D. C., Standard Forms of, Eng. News, 1-17-1885.

Stent, Wm. Kitson, On Rainfall Discharged from Catchment Areas, Proceedings Inst. C. E., Vol. 119, p. 273.

Storm Flows from City Areas and Their Calculation, Eng. News, Vol. 48, p. 386.

Storm Water, Determination of Amount of, Ill. Soc. Eng. & Surv., 1894, Vol. 9, p. 64.

Storm Water Runoff, Additive Method of Determining, Eng. News, Vol. 61, p. 265.

Storm Water Runoff, Additive Method for Determining, Eng. Rec., Vol. 59, p. 265.

Storm Water Runoff, An Additive Method of Determining, Eng. Rec., Vol. 59, p. 265, 1909.

Storey, W. B., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1017.

Sullivan, J. G., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1017.

Survey, U. S. Geol. 20th Rept., pp. 46-64; Records of 225 Streams in Various Portions of United States.

Talbot, Arthur N., Determination of Amount of Storm Water, Ill. Soc. Eng. & Surv., 1894, Vol. 9, p. 64; Rates of Maximum Rainfall, Technograph U. of Ill. No. 6, 1891-92, p. 103; Relation Discharging Capacity of Brick and Pipe Sewers, Ill. Soc. Eng. & Surv., Vol. 18, p. 63; Determination of Waterway for Bridges and Culverts, C. E. Club, Ill. (Selected Papers No. 2), p. 14.

Tile Drains and Open Ditches, Capacity of, Eng. News, 9-4-86.

Tripp, Wm. Blomefield, River Buffalo; Total Flow at Town Dam, King William's Town, Cape of Good Hope, from June, 1880, to March, 1883, Compared with Rainfall, Proceedings Inst. C. E., Vol. 81, p. 241.

Turneaure and Russell, Public Water Supply, p. 49.

Velocities and Discharge by Red Float Methods, Canadian Soc. C. E., Jan. to June, 1896, p. 129.

Velocity of Streams Flowing in Natural Channels, The Mean, Trans. Am. Soc. C. E., Vol. 11, p. 186.

Vernon, Harcourt, The River Seine, Proceedings Inst. C. E., Vol. LXXXIV, p. 210.

Walker, I. O., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1017.

Water Supply, Public, Turneaure and Russell, p. 49.

Water Supply Engineering, A Treatise on, (1878) Ed. (J. T. Fanning).

Waterway for Bridges and Culverts, Determination of, C. E. Club, Ill. (Selected Papers No. 2), p. 14.

Waterways for Railroad Culverts and Bridges, Areas of, Jour. W. Soc. Eng., Vol. 11, pp. 137 and 797.

Waterways, A Comparison of Bridge, Proceedings Ind. Eng. Soc., 1909, p. 46.

Waterways, How to Determine the Size and Capacity of; Openings of; Proceedings Assoc. Ry. Supts. B. & B. 7th Annual Convention, 1897.

Waterways, Method of Computing Cross-Section Area of, Water Supply and Irrigation Paper No. 147, p. 182, U. S. Geol. Survey, 1905.

Waterways, The Size of, The Best Method for Determining, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, pp. 967-1022.

Waterways for Culverts, Proper Amount of, Proceedings Inst. C. E., Vol. 58, p. 375.

Waterways to Drainage Areas, Relation of, Ill. Soc. Eng. & Surv., Vol. 23, p. 66.

Waterway to Drainage Area, Relation of, Eng. Rec., Vol. 57, p. 138.

Weber, Wm. A., Rainfall and Runoff of the New England Atlantic Coast, and Southwestern Colorado Streams, Jour. Assoc. Eng. Soc., Vol. 31, p. 131.

Wellington, A. M., Economic Theory of Railway Location, pp. 781-83.

Wentworth, Charles C., Formula, Ry. Gaz., 1903, p. 57.

Wentworth, C. C., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1019.

Whitney, S., Determining Size of Railroad Culverts, Ry. Gaz., 1902, p. 976.

Willoughby, J. E., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1020.

Wing Wall of Bridge Abutment, To Ascertain Best Angle for, Ill. Soc. Eng. & Surv., Vol. 11, p. 156.

Wood, B. A., discussion by, Proceedings Amer. Ry. Eng. & M. W. Ass'n, Vol. 10, p. 1020.

Appendix D.

RIVER PROTECTION WORK.

(Bulletin 128.)

By C. H. Miller, Engineer River Protection, Missouri Pacific Railway.

Those present at the annual meeting of March, 1909, will recall the discussion with regard to an additional conclusion to be placed under the heading of "Slides" and having reference to the restoration of the toe of a slope where that toe has been scoured away. The Committee contended, and properly so, that this was only a special case, and was fully provided for under the general conclusions, and that to add something of this kind would be a repetition; this contention was sustained by the convention as a whole.

The writer would not only repeat this feature but would call special attention to it by printing it in boldfaced type. There is scarcely any other one item in maintenance of way work that is so often handled in an unnecessarily expensive manner; and this, too, in many instances where the matter has been covered by instructions on the subject. It is highly desirable that we formulate instructions in our Manual that are plain and concise, that cover the subject thoroughly and no more, but it is more important, and our chief aim besides, to prevent a waste of funds. In this instance we seem to be confronted with a condition requiring special treatment, and it should be handled accordingly, subject to correction or elimination when it is safe to do so.

These notes apply particularly to slides taking place along constantly flowing streams of moderate velocity, and not to the intermittently torrential streams which at times run at the rate of 10 ft. or more per second; these latter requiring special handling.

With such slides as are under discussion it is too often the case, in fact it seems to be the rule rather than the exception, to simply dump on top of the same sufficient riprap to fill out the sunken part so as to restore the original form of the embankment, no effort being made to place riprap at the toe of the slope and over the same to prevent future scour and the consequent removal of the support for the increased weight above.

The very fact that a great number of such slides do hold to their new positions in spite of this treatment is often cited as the correctness of the same. When a little reasoning would soon show anyone that piling heavy material on top of a recent slide does not tend to stop the sliding, and the reason that it does not at once start it again is probably due to the fact that the sliding material while in motion went considerably past the point of equilibrium before the motion ceased, and that considerable additional weight would be required to start it as long as the new toe of the slope remains intact.

A thin layer of riprap will protect against erosion in the ordinary streams of the Middle West, and so long as there is sufficient additional riprap at the toe of the slope to protect against the increased depth of scour due to the presence of the riprap or projection, a permanent protection is secured.

In the case of a double or four-track line, one can well afford to be sure about this surplus by placing more than would ordinarily be required to cover the assumed additional slope. But most of the roads operating in the alluvial valleys of the West cannot at this date well afford to thoroughly protect with riprap, even if, which is seldom the case, a secure foundation can be found. It should be quite evident, therefore, that filling in on top of a slide with riprap simply to restore an embankment is a much worse practice; riprap costing not less than twice as much as a more suitable material, namely, earth, or, better still, cinders, because of their light weight.

In cases where water appears on top of the slide, careful provision should be made so as to allow it to run off between the top of the slide and the bottom of the new filling, care being taken that no pockets of any kind that would hold water are left on top of the slide. A very good practice before the filling is made is to place tightly bound bundles of straight brush so that they will act as drains to take care of any water that may be there.

Among the replies on the subject of "Slides and Washouts" presented by the Committee on Roadway as Appendix "C" in Bulletin 108, we note the statement that the cost of revetment on the Mississippi River ranges from $60 to $80 per linear foot. These figures being so much above the actual cost of this class of work, it is deemed advisable to present figures taken from the actual cost of works constructed under the supervision of the writer as well as those from revetments of which the writer has intimate knowledge, with the hope of correcting any wrong impression that the former figures may have given.

The following figures are taken from the published reports of the Chief of Engineers, United States Army. Unfortunately the system of reporting costs has not always been uniform from year to year; this refers especially to the cost of repairing and maintaining the plant and equipment; the costs of construction works have, uniformly, been kept more accurately. Where there is a doubt as to the actual expenses, account of plant, assumptions are made on the safe side, or rather the maximum figures are taken.

The same amount of plant, approximately, is maintained from year to year, irrespective of the fact as to whether or not it is at all times worked to its full capacity during the working seasons. When we say plant, we include docks, machine shops, carpenter shops, etc., as well as the part of the plant actively engaged in construction works. There being such a great difference in the amount of construction work accomplished in any one year over another, it has been deemed best to take the average for a continuous period of five years, and two such periods have been arbitrarily selected without any regard whatever as to a great or small amount of work having been done during these periods.

The first and second districts are combined under one officer and extend from Cairo, Ill., to the mouth of White River. Another officer has charge of the third district, which covers the territory from the mouth of White River to Warrenton, Miss., or about eight miles below Vicksburg, Miss.

During the period of 1904 to 1908, inclusive, there was expended in the first and second districts an average annual amount of $176,957 for construction or protection works (this includes $5,015 for surveys), and $72,119 for repairs, care and depreciation of plant, the latter amount being about 41 per cent. of the amount expended on the work. In the third district for the same period an average annual amount of $152,019 (including $5,500 for surveys) was expended for protection works, and $45,428 for repairs, care and depreciation of plant, this being about 30 per cent. of the money spent for construction.

Going back to the period of 1891 to 1895, inclusive, being a time when more work in proportion was accomplished with the same or similar plants, we have for the first and second districts an average annual expenditure of $311,530 for protection works and $53,561 for plant, or 17 per cent.; and for the third district $250,062 and $58,994, respectively, being about 24 per cent. We average these four percentages, getting 28 per cent.

A very large part of the amount expended each year is for repair work, but in endeavoring with the information at hand to arrive at the proportional cost for maintenance of plant as compared with the cost of new work we will assume that all of the money was expended for new work, then take the cost per linear foot on such large pieces of new work where there is no doubt about the records, and add the percentage as deduced above to get the total actual cost per foot.

In the first and second districts we note some new work costing as little as $18.32 per linear foot and others as much as $43.08 per foot. While in the third district it varies from $27.08 to $36.31. We will assume an average of $33; now adding 28 per cent we get $42.25 per linear foot as the total cost of revetment work on the Mississippi River.

The present value of one of these plants is in the neighborhood of $225,000, the original cost probably about $350,000. The charges against plant may appear high, but as a rule they include moneys spent for new plant replacing worn-out items; in fact it is the cost of maintaining the plant up to a serviceable standard all the time.

Revetment work as now constructed, even under the best known plans, is not permanent, and must be reinforced and repaired from time to time. In many instances the cost of repairs and replacements has been several times what it should have been because of the delay in making them, or because the river was allowed to flank and cut out much serviceable work.

Very few reports have been made covering the average cost of repairs;

but from the 1908 report for the third district we abstract the following facts or statements to the effect that repairs and reinforcements of revetments of the approximate present value of $1,500,000 have cost during the past three years an average of $76,700 annually, or 5.1 per cent., not including maintenance of plant, which was about 2.6 per cent. annually.

From a professional paper discussed before the Memphis Engineering Society a year or two ago we abstract the following with reference to what is known as the solid fascine type of mattress built in the third district during the years 1895 to 1906, inclusive: Cost of maintenance and repairs, 1.83 per cent. per annum, and the cost of plant depreciation, 0.9 per cent., or a total of 2.73 per cent. per annum for the ten years.

The mattress work on the part of the Mississippi River in question varies from 200 to 300 ft. in width, an effort being made to place all of this below the ordinary low-water contour; in addition riprap paving is placed on the slope above this contour and to a width of from 60 to 100 ft., the slope having previously been graded to a uniform grade.

Of the figures given for the Missouri River, viz., $12 to $20 per linear foot, the minimum is not far wrong, but the maximum is much too high. At the present writing we are placing standard revetment work in the vicinity of Pope, Kan., by contract for approximately $7 per linear foot (the mattress is not being made 86 ft. wide, but the unit prices have been applied so as to get the cost for such a mattress). At Congo, Mo., two years ago the Santa Fe Railway Company contracted a small piece of revetment work which totaled about $10 per linear foot. Both cases being contracts, the prices given take care of wear and tear on plant as well as profit.

All through the reports of the Missouri River Commission one can find the costs of new work, and they seldom go as high as $10 per foot, being generally below $8; by adding 28 per cent. for care, maintenance and renewal of plant we still are below the minimum of $12 first cited.

Regarding the statement about the range between high and low water being small on the Missouri River, and referring to other rivers as well, we submit the actual figures which show the extreme range of gage heights at the points mentioned as follows:

Missouri River: Kansas City, Mo., 33.5 ft.; Hermann, Mo., 31.3 ft.

Mississippi River: St. Louis, Mo., 42.5 ft.; Cairo, Ill., 53.2 ft.; Helena, Ark., 54.8 ft.; Red River, La. (mouth), 50.8 ft.

White River: Jacksonport, Ark., 34.5 ft.

Arkansas River: Little Rock, Ark., 33 ft.

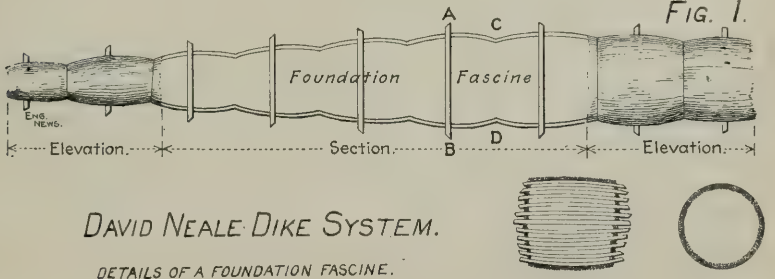
Red River: Alexandria, La., 42 ft.

This extreme range rarely if ever occurs within any one year; and it is safe in figuring that it will be five to ten ft., or more, less.

At one place in Bulletin 108 mention is made of a system of anchor riprap for protecting caving river banks. This as originally conceived and constructed consisted of a deflection dike or a series of dikes placed along the caving bank and built of brush, wire, spikes and cable in such a manner as to leave large hollow cells for the collection of mud; not one pound of rock or riprap being used, so therefore in this respect the name is a misnomer. Some riprap is now often used for the top bank protection as well as to weight down the dike if, when completed, there is a considerable part of the same above the surface of the river.

An article by the writer which was published in Engineering News under date of October 22, 1908, discusses this system as compared with other styles of protection work. The following detailed description of the manner of building the work is copied from that article; the cuts or figures referred to were published also; but it is possible to get an understanding of the work without seeing the cuts. The brush for this work need not be carefully selected, but may be quite variable as to quality, size and shape. With a supply of this material on hand, we place a layer 6 to 12 in. thick, 40 to 100 ft. long, and 5 to 10 ft. wide, upon a barge or upon the river bank, taking care to have this layer upon poles a proper distance apart so that wire and cable or strand can easily be passed back and forth underneath the whole, the brush to be laid closely and with broken joints. Across this layer or bed place bundles of brush 6 to 8 in. in diameter, 7 to 12 ft. long and 5 to 10 ft. apart as the case may be; the ends of these cross bundles should project about a foot over each side of the brush bed. Now along each longitudinal edge of the bed and on top of the cross bundles place a continuous bundle or fascine of brush of similar thickness to the cross bundles, next more cross bundles directly above the others, then longitudinal bundles, and so on until the whole is from 5 to 10 ft. high. In a few words, build up as though it were a rail or pole pen, except that in this case a long pen with partitions is made, care being taken to have the ends of the poles or bundles project out a foot or more. When the brush has no leaves, interstices will be left between the bundles. Fill these with brush tops, hay, straw or cornstalks so as to present comparatively tight sides and partitions. On top of the whole place a brush cover or top similar to the bottom bed. With a suitable appliance, next compress and bind tightly with wire or wire strand at intervals of from 5 to 10 ft., producing a large cellular fascine or bundle of hollow cells. The smaller dimensions will give the minimum and the larger ones the maximum size of fascines as generally used on the Missouri River to-day. The description would indicate a cylindrical or straight-edged

FIG. 1.



DAVID NEALE DIKE SYSTEM.

DETAILS OF A FOUNDATION FASCINE.

Cross Section A-B. Cross Section C-D.

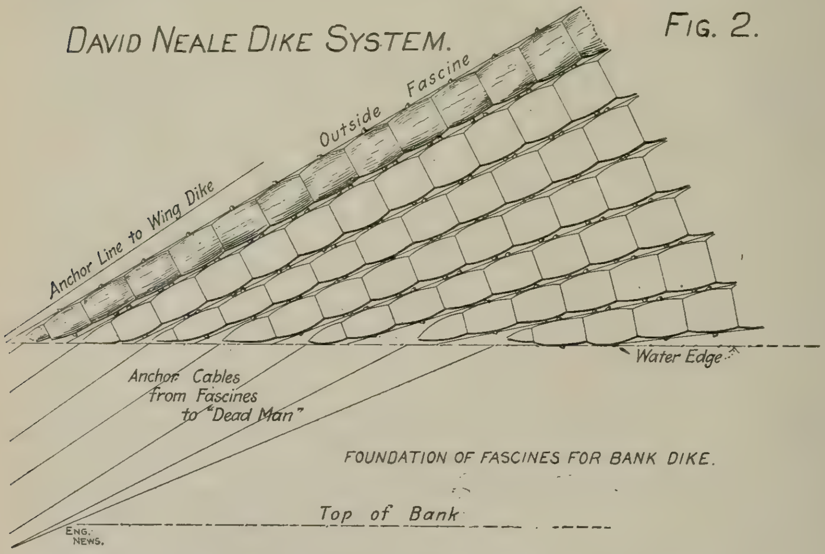
construction, but in actual practice the fascines are built cigar-shaped, which gives them increased strength to resist crushing before they are entirely filled with mud. (Fig. 1.)

After securing the upper or smaller end to a dead-man or post by means of a line or cable, the bundle is launched into the river and floated into place. Within a day or two it will collect enough mud to cause it to settle to the bottom. If not, bags of sand or a sand pump may be used. When once on the bottom it soon becomes securely anchored into the sand through the agency of the currents and the process of filling is soon completed. Not one pound of rock is necessary to accomplish this result.

This as described constitutes one of the units. They can be placed side by side and one layer on top of the other to build up a large deflection dike. The usual practice, however, in constructing such a dike is to build from 6 to 10 of these large cigar-shaped units in progressive lengths of from 30 to 100 ft. and then launch them in such a manner as to form a large triangular-shaped mattress, the upstream being a point against the bank at the water's edge, the downstream end extending out from 30 to 100 ft. on the surface of the water, and the outer edge or side of the triangle being at an angle of from 30 degrees to 40 degrees with the bank line. (Fig. 2.)

DAVID NEALE DIKE SYSTEM.

FIG. 2.


Outside Fascine
Anchor Line to Wing Dike
Anchor Cables from Fascines to "Dead Man"
Water Edge
FOUNDATION OF FASCINES FOR BANK DIKE.
Top of Bank
ENG. NEWS.

On top of this mattress is now started what may be termed a mud-cell raft, the outer edge and lower end being set back from 5 to 8 ft., having a step of that size around these two sides. This raft is built exactly after the manner of the fascines but is continuous, as there are no short bundles of brush except toward the upper point of the mattress. In other words, it is built after the manner of a log house with many rooms, with the rooms from 5 to 8 ft. square. This raft is extended in and over the upper slope of the bank as it is built up in height, the slope having previously been graded to 1 on 1½. For about every 5 ft. of elevation around the outer edges step back, as mentioned before, finishing the part left out with a covering of brush. Keeping the top of this work on about a 1 on 5 slope, the upbuilding continues, if possible, until the dike ceases to settle, when a brush covering is placed over the whole, with heavy poles on top placed up and downstream to ward off drift and ice. If the dike eventually sinks, more work can be placed on top.

The brush is not always carried to the top of the bank, but riprap is used to make this part more permanent. It can readily be seen that except along the outer edge and on top there is no further use for the wire fastenings. If extra care is taken to secure these parts of the dike with heavier wire strand, or by bolting heavier poles so that they will prevent the brush from becoming loose, the life of the work is much prolonged. (Fig. 3.)

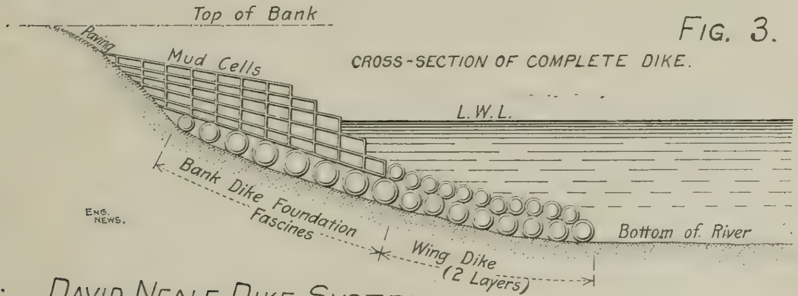


FIG. 3.

CROSS-SECTION OF COMPLETE DIKE.

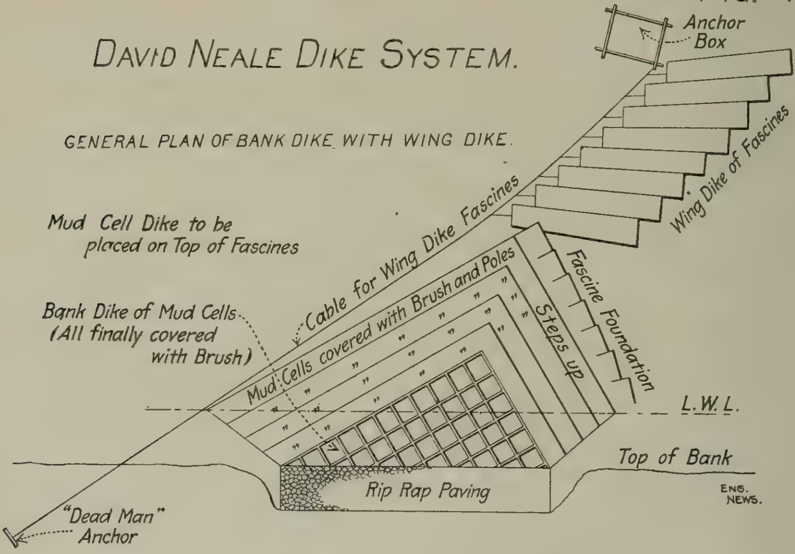
DAVID NEALE DIKE SYSTEM.

The steps referred to above have the effect of very materially reducing the eddy action below the dike; in fact they nearly eradicate the same when properly constructed. Experience, however, is necessary to accomplish this result. The effect of the dike is to cause the water to glide off smoothly and to deflect slightly the main current from the bank. In order to more thoroughly deflect the lower currents and to prevent excessive scour at and below the outer corner of the bank dike, a mattress of the smaller sized fascines, the whole commonly called a wing dike, is next constructed in the following manner (see Fig. 4): To the outer end of a strong cable attach and sink a Chinese anchor or mud box, in a position about 40 ft. below and 50 ft. outside of the outer corner of the bank dike. This cable is securely fastened to a dead-man on the bank about 100 ft. above the upper corner of the dike already placed. Cellular fascines about 30 ft. long are built and fastened to this large cable with a short piece of cable and a slip ring, and when launched overboard are carried down by the current and sunk into place one after the other by the weight of the sediment they collect.

The space between the Chinese anchor and the bank dike is completely covered or filled in, two or more lead cables being placed if necessary to accomplish this result. Dependent upon conditions, and the amount of deflection it is desired to give the river at this particular point, these fascines can be piled in one layer over the other. Care must be taken in building the fascines for the wing dike, particularly the ones that will come on top, to make them strong and to bind them with heavy strand or poles in such a manner that they will not soon come apart. The dike next down stream can now be located just about the point at which the currents again strike the bank. The distance varies very much, dependent upon conditions.

Repairs to this work usually consist in replacing the top cover and in strengthening the upper bank work; also in building up a dike that has settled unduly. It appears that nearly all of the settlement takes place during the first season of high water.

FIG. 4.



DAVID NEALE DIKE SYSTEM.

GENERAL PLAN OF BANK DIKE WITH WING DIKE.

Anchor Box
Mud Cell Dike to be placed on Top of Fascines
Bank Dike of Mud Cells (All finally covered with Brush)
Cable for Wing Dike Fascines
Mud Cells covered with Brush and Poles
Wing Dike of Fascines
Fascine Foundation
Steps up
L.W.L.
Top of Bank
Rip Rap Paving
"Dead Man" Anchor
ENG. NEWS.

Further along in the article from which the foregoing has been copied mention is made of the eddies usually induced by these dikes, and the question is raised as to whether or not the expense necessary to protect against these eddies will not cause this system of work to cost as much as continuous work. We have had some more experience with this work since writing the article for the Engineering News, as well as having observed the action of the older works; and although we are now reasonably certain of getting a filling in, below the dike, to a height slightly above the low water level and extending a considerable distance down stream, we have failed to entirely eradicate the eddy during high stages, and are placing upper bank mattress to prevent the dike from being cut down from behind. The trouble with this upper bank mattress being that it may be expected to rot out in the course of a few years. Quite recently the writ-

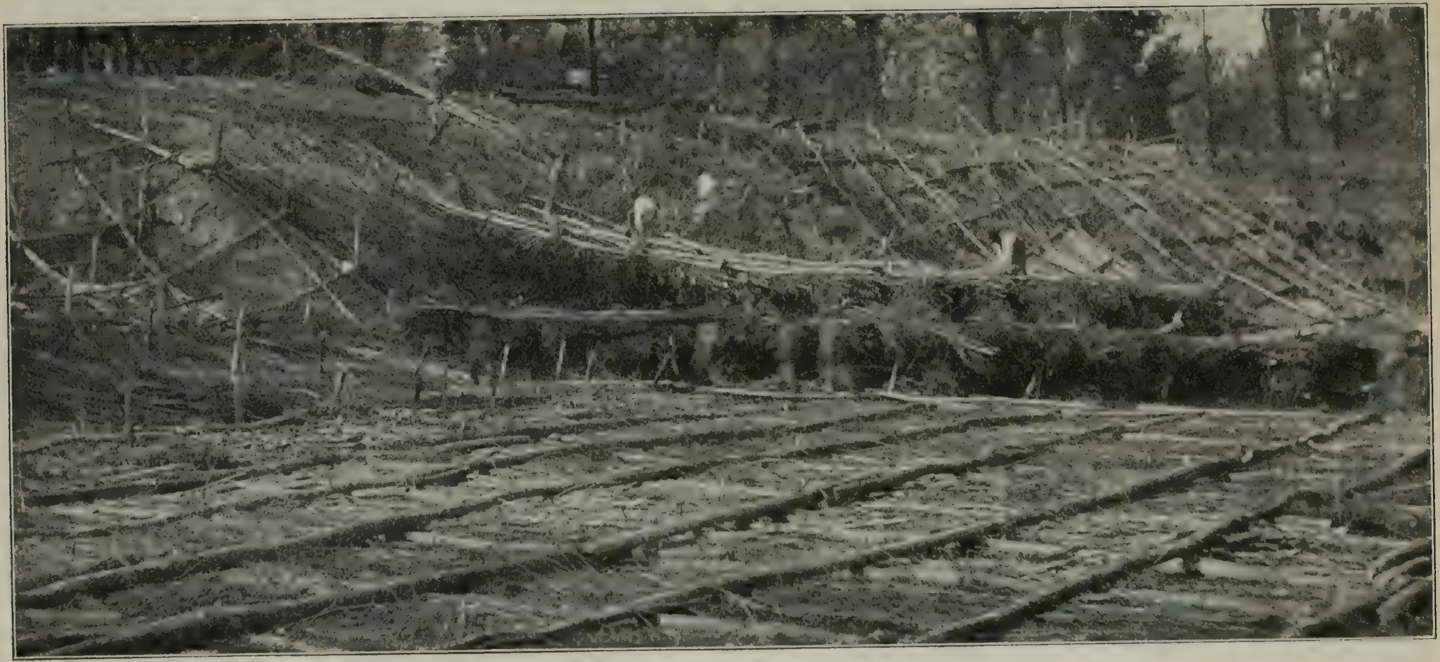


Fig. 5.—Near View of a Foundation Mattress, the Dike in Middle Being Just Started.

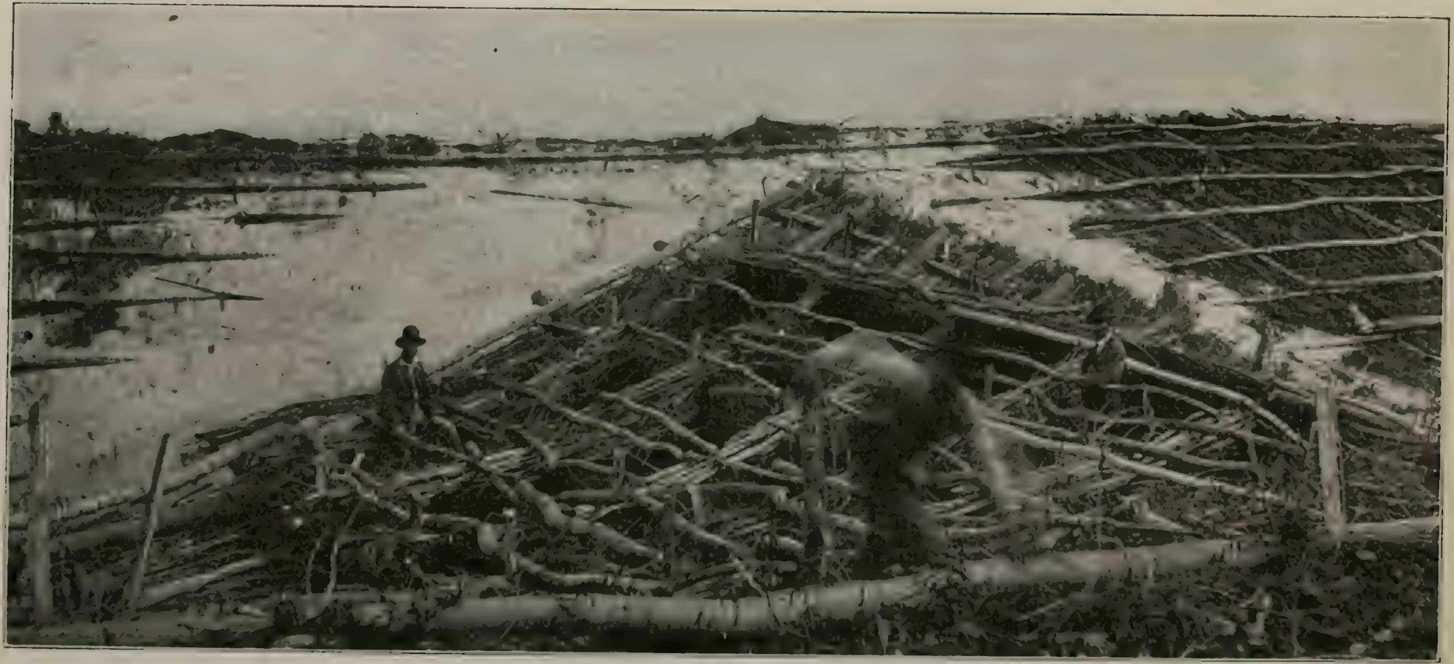


Fig. 6.—Foundation Mattress Partially Submerged.

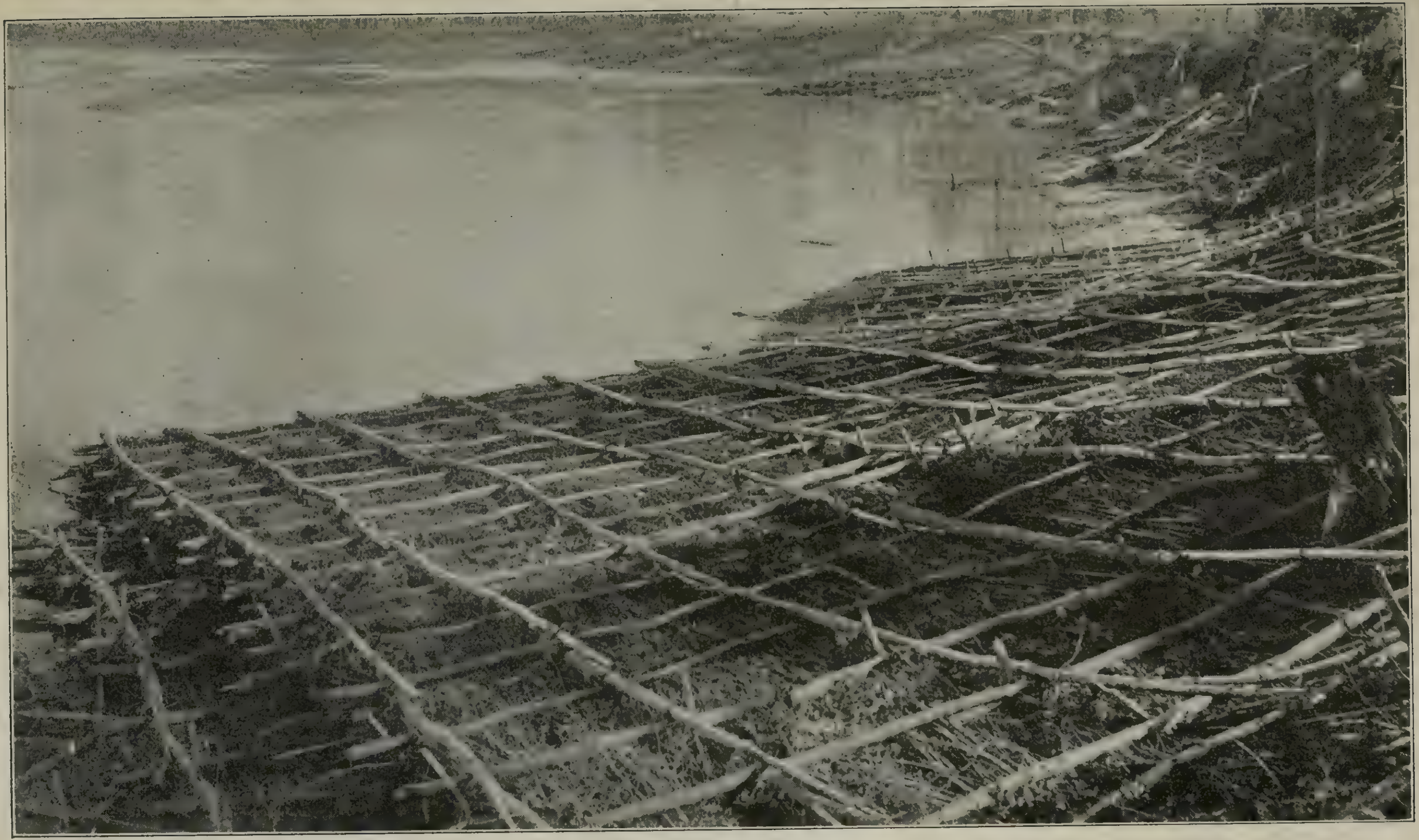


Fig. 7.—Completed Dike.

er's attention has been called to a patent system of reinforced concrete mattress work; this we are now investigating, and hope to have some definite facts and figures to present by the date of the next annual meeting. It would seem, however, from the cost figures as presented by the promoters that this concrete mattress can be constructed at a figure well within reasonable and economical consideration. A combination of this mattress with the mud-cell or fascine dike ought to give reasonably long-lived work.

Instead of using the fascine foundation previously described, we are now in many cases simply building a foundation mud-cell mattress and starting the dike on top; this is the method always used when the water does not contain so much sediment as to cause the mattress to sink too rapidly to allow sufficient time to get the dike started. Also, since at the present time it is deemed best to at once construct the protection work against eddy-action above and below the dike, the mattress is started 75 or more feet above the proposed location of the dike and carried through to a point 100 ft. or more below the same.

In a few words, this mud-cell mattress consists of two tight layers of brush, the upper one being one foot or more above the lower one. This requires much more brush than the ordinary standard mattress, as a rule, but is offset by the fact that no rock or riprap is required; we have not yet collected sufficient reliable figures to submit an estimate of this difference.

All styles of mattress work require one or more barges or floating plant to construct, and in many localities it is almost impossible to rent suitable ones. A railway company having only an occasional job of this kind cannot afford to build barges. The fascine type requires no floating plant except a small scow to sink the Chinese anchor, but the wing dike is not always required; and this scow can be built for $75. All materials can be assembled by work train.

To get a good job of continuous mattress work it is necessary to place the same at a low stage of river, and to pave the upper slope with riprap. The fascine system can be placed at any stage that does not go much above the natural banks, and will last just as long as if it were placed at a low-water stage. For emergency work, at points where the river is attacking very rapidly (being usually when there is a high stage) we know of no other means or system that will in any way compare with the cellular fascines in checking this caving and for holding the position. There is not sufficient time to assemble the necessary plant for placing the standard mattress work, and, as a rule, the current of the stream is too swift to allow of the holding of the plant in place if you did have it on hand. The fascines can be placed separately as fast as made, each one anchored to the bank with sufficient fastenings to hold it in a swift current until it settles to the bottom, where it will remain by its own weight. It is simply a question of getting men and materials (brush, wire and cable) in sufficient quantities. It will be readily understood that this system is chiefly applicable on the heavily silt-laden streams; if the stream does not carry much silt, a few sacks of sand or loam will suffice to sink the work to the bottom, where it will the more quickly become entirely full of mud.

The dike system lends itself more readily to the plan of placing only a part of the protection in any one year, and adding to as the caving progresses or as it is found to be necessary; thus spreading the cost out over a greater length of time. With the mattress work or system of solid protection it is usually necessary to place a greater extent of work, because the losses on account of flanking are likely to be greater than with the dikes.

An error very often made is to protect a long stretch of bank when it is only a short piece in the middle of the same that is near to the track, and when the rate of caving is such that it would be utterly impossible for the same to reach the track in the course of a year or two at least. To omit the protection of that part of the bank that is beyond the limits of one season's caving (particularly that which is above the danger point) will permit the river to straighten itself out more or less, materially reducing the force of impact or caving near the track, and tending, by reason of the work then in place, to throw the river away entirely from that part of the bank that is below the point of original attack. The most severe attack is constantly being followed up with the newer work, besides there is always a possibility with most of such rivers that changes may occur to cause the attack to cease entirely, and a great saving will be had over placing protection through the entire bend at the first season.

So very many conditions and factors enter into this class of work that it is impossible to lay down any set rules to go by, and each case must be treated as a special one; and it is very seldom possible to predict with any degree of certainty what results you will get from any particular system or method.

Cost records covering this style of protection are not extensive enough to give much reliable information, neither do they date back far enough to enable us to determine the probable cost of repairs, and at some of the points we were obliged to use the solid mattress system in conjunction with the mud-cell system, because the river had caved up to the ends of the ties, making it unsafe to use the dike system alone; and the records could not be kept separate.

At Myrick, Mo., the first work was placed in August, 1906; some of the dikes are more than 1,000 feet apart (a greater distance than they should be, we have since learned), a total distance of 5,100 feet of bank was covered, much of it nearly straight, and some of it near the bluffs; altogether not a very reliable test. The first season's work cost $9,204.65; the following year $1,677.76 worth of repairs were made; and during the season just passed, $2,749.61 was spent in additions, making a total of $13,632.02, which amounts to $2.67 per linear foot.

At a point about two miles east of Wooldridge, Mo., four dikes were placed during the present season at a total cost of approximately $10,000, covering 2,525 linear feet of bank, which equals $3.96 per linear foot.

At Sandy Hook, Mo., during the past year 2,950 linear feet of bank was covered with mattress, and three dikes placed on top at different points, at a total cost of $14,044.18, or $4.76 per linear foot.

At Marion, Mo., during the past two years much extraordinary work was put in on account of severe caving, and 3,150 linear feet of bank is protected, mostly with solid mattress work. Total cost, $25,498.13, or $8.09 per linear foot.

Contractors are to-day taking work at $4.50 to $5.00 per linear foot of bank protected.

DISCUSSION.

(In the absence of the Chairman and Vice-Chairman of the Committee, the report was presented by Prof. W. D. Pence, University of Wisconsin.)

Prof. Pence:—The only matter on which the Roadway Committee had reached a fairly definite opinion was that of the waterways for culverts. The matter has been under investigation for several years and the conclusions are presented on page 90 of Bulletin 133. In view of the fact that the matter here presented was not fully discussed by the Committee, there being but a small attendance at the meeting at which it was submitted, it seemed desirable that this should be accepted as information and that the Committee be allowed to consider the matter further in connection with the hydraulics of the culvert, which it has suggested in the body of the report to be submitted next year. The matter presented on page 90 touches upon the question of finding general formula for waterways. This is a matter which will always be a fruitful one; it is a subject which will not down, and in view of its importance in connection with culvert work, as well as in the design of culverts, in the substitution of permanent for temporary structures, it is believed it will **not be** an unfit thing to consider it somewhat more at length in connection with the matter just mentioned—the hydraulics of the culvert.

Mr. Chas. S. Churchill (Norfolk & Western):—I move that the report be received as information. I believe the plan of the Committee is the best one for the future. There should be an investigation of waterways over the United States with a view to finding a general formula by which a change in the co-efficient will be applicable to different sections of the country; and I believe that this Committee is in better shape to work out such a formula than any other body. I hope they will go on with the good work they have started with this compilation, its comparisons and its very valuable information.

Prof. Pence:—May I add a word? If the Committee may have the support of the members of the Association in connection with this matter of districting the country, by responding to the circular which the Committee plans to send out by platting a few points on the diagram, shown on page 87, it is believed that considerable progress can be made. The diagram on page 87 is really a remarkable thing. That is graphic representation of the data gotten together by the late James Dun. It represents something upon which we may perhaps be able to string results.

Mr. J. L. Campbell (El Paso & Southwestern):—In the El Paso & Southwestern formula the co-efficient 12 should be 17. In the original form as developed by Mr. Frizell, the co-efficient was 17.35 and the quantity 8000 under the radical was 8006

Prof. Pence:—In view of the probability of typographical errors in any compilation of this kind, the Committee would further request that criticisms, such as has been made by Mr. Campbell, be sent in to the Secretary of the Association, so that this may be corrected before it is published in the Proceedings.

Mr. Churchill:—I wish to call the attention of the gentleman who just spoke, that the formula to which he refers practically reduces to Myers' formula.

(The motion was carried.)

The President:—The attention of the Association is called to the important matters on pages 108 and following, being a bibliography on the subject of waterways.

Mr. William McNab (Grand Trunk):—I think this is a very valuable part of the report and I would like to compliment the Committee on presenting to us this bibliography.

The President:—The Committee makes one recommendation which ought to be acted on. It recommends that the following clause be inserted in the conclusions heretofore adopted in relation to Tunnels: "The height of rail shall, in all cases, be assumed as six inches." If there is no objection, that will be added in its proper place in the Manual.

If there is no further discussion on this Committee's work, it will be relieved with the thanks of the Association for its excellent report.

SPECIAL COMMITTEE ON GRADING AND INSPECTION OF MAINTENANCE OF WAY LUMBER.

(Bulletin 133.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Meetings of this Committee were held in Chicago on November 2 and January 16. At the November meeting the following members were present:

W. H. Sellew, Chairman.
B. A. Wood.
E. O. Faulkner (represented by A. F. Robinson).

And at the January meeting:

W. H. Sellew, Chairman.
Dr. Hermann Von Schrenk.

Both of the meetings were held jointly with the Committee on Lumber Specifications of the Railway Storekeepers' Association, and at the November meeting several of the Manufacturers' Association were represented.

In the classification of lumber the question of the absence or presence of defects is of the greatest importance, and the various Lumber Associations of the country have adopted standard grades for the kinds of lumber which they manufacture, according to which they grade their product by sizes and by the quality, as determined by the absence or presence of certain standard defects.

To insure uniformity, it is obviously desirable that in ordering and purchasing lumber, the railroads follow standard specifications which shall be considered as such by both the producer and consumer. This principle has been recognized by the Association in the adoption of the Standard Specifications for Southern Yellow Pine Bridge and Trestle Timbers, which are now the standard specifications of the Yellow Pine Manufacturers' Association and of the American Society for Testing Materials.

Since the adoption of these Standard Specifications, the Yellow Pine Manufacturers' Association and American Society for Testing Materials have issued these Standard Specifications in the form of a small pamphlet, and the manufacturers have attempted to live up to these specifications in the manufacture of grades of timbers applied to bridge and trestle construction.

Apart from these specifications, comparatively little has been done in the way of formulating standard rules for the grading of Maintenance of Way lumber that are recognized both by the railroads and manufacturers.

In Bulletin No. 71 of the Forest Service are given rules and specifications for the grading of lumber adopted by the various Lumber Manufacturers' Associations of the United States. Since the publication of the Bulletin, in 1906, practically all of the rules it contained have been revised, and for this reason, the Bulletin at the present time has little practical value.

The following organizations of Lumber Manufacturers have for the last year assisted the various Railroad Associations in their work of standardizing lumber grades. These Associations represent a large percentage of manufacturers engaged in the production of lumber products:

ASSOCIATED BUREAU OF GRADES, comprising the Pacific Coast Manufacturers' Association, Southwestern Washington Lumber Manufacturers' Association, Oregon and Washington Lumber Manufacturers' Association.

NORTHERN PINE MANUFACTURERS' ASSOCIATION: This Association deals in White Pine and Hemlock, with headquarters at Minneapolis, Minnesota.

YELLOW PINE MANUFACTURERS' ASSOCIATION: This Association, with headquarters at St. Louis, Missouri, is composed of the principal operators in Yellow Pine lumber throughout the South.

HARDWOOD MANUFACTURERS' ASSOCIATION OF THE UNITED STATES, with headquarters at Cincinnati, Ohio, sets standard grades of Poplar, Oak, Cotton Wood, Gum, and other Hardwoods. During the past year this Association, through an agreement with the lumber dealers in the eastern states, sets the grades in this territory as well as throughout the middle and southern states.

SOUTHERN CYPRESS MANUFACTURERS' ASSOCIATION, with headquarters at New Orleans, Louisiana, is composed of operators dealing in Cypress products.

At the 1909 convention of the Master Car Builders' Association a Committee was appointed to act in conjunction with similar Committees from the American Railway Master Mechanics' Association, Railway Storekeepers' Association and the Lumber Manufacturers' Associations throughout the country and to prepare specifications and grading rules for car and locomotive lumber.

At the 1910 convention of the Master Car Builders' Association a report was submitted on this subject, which was subsequently adopted by the above referred to Railway and Lumber Manufacturers' Associations. This report consisted of a description of the various woods used by the railroad companies for car and locomotive lumber, a list of standard defects, with appropriate photographs illustrating these, and the grading rules for each kind of lumber.

A great deal of the matter contained in these specifications is applicable to Maintenance of Way lumber, and several of the Manufacturers' Associations have submitted to this Committee specifications for Maintenance of Way lumber, using the descriptions of woods and standard defects already adopted by these Associations. These specifications are printed in full as an appendix to the report.

In submitting these specifications *as a matter of information* to members of this Association, the Committee wishes to emphasize that it is desirable to adopt a series of specifications of this character at the earliest possible date. The splendid results obtained from the joint adoption of such standard rules for bridge and trestle timbers has already been pointed out. The various Lumber Associations have indicated their readiness to co-operate with the members of this Association for the purpose of having similar rules adopted for Maintenance of Way lumber.

The Committee suggests that the work assigned to it for the next year consist in the preparation of similar specifications for classes and kinds of lumber not included in the specifications submitted in this year's report, and the consideration of those submitted with a view towards recommending the adoption of Standard Specifications for Maintenance of Way Lumber.

Respectfully submitted,

W. H. Sellew, Principal Assistant Engineer, Michigan Central Railroad, Detroit, Mich., *Chairman.*

F. H. Bainbridge, Resident Engineer, Chicago & Northwestern Railway, Necedah, Wis.

E. O. Faulkner, Manager, Tie and Timber Department, Atchison, Topeka & Santa Fe Railway System, Los Angeles, Cal.

R. Koehler, General Purchasing Agent, Southern Pacific Lines in Oregon, Portland, Ore.

Dr. Hermann Von Schrenk, Supervisor of Timber Preservation, Frisco Railway System, St. Louis, Mo.

B. A. Wood, Chief Engineer of Maintenance, Mobile & Ohio Railroad, Mobile, Ala.

Committee.

Appendix A.

CLASSIFICATION AND GRADING RULES FOR DOUGLAS FIR.

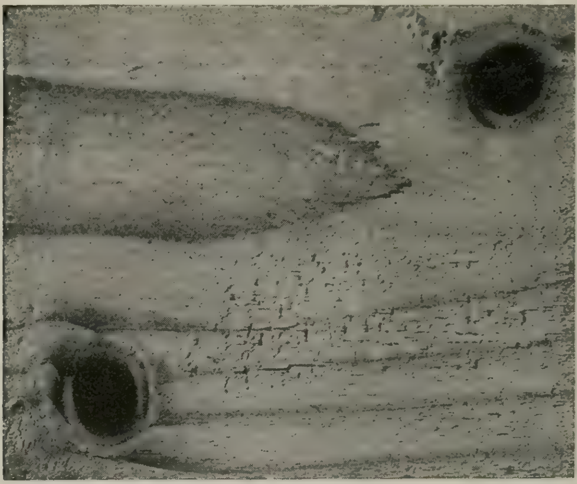
1. The term "Douglas Fir" will cover the timber known likewise as Yellow Fir, Red Fir, Western Fir, Washington Fir, Oregon or Puget Sound Fir or Pine, Northwest and West Coast Fir.

2. *Fir Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

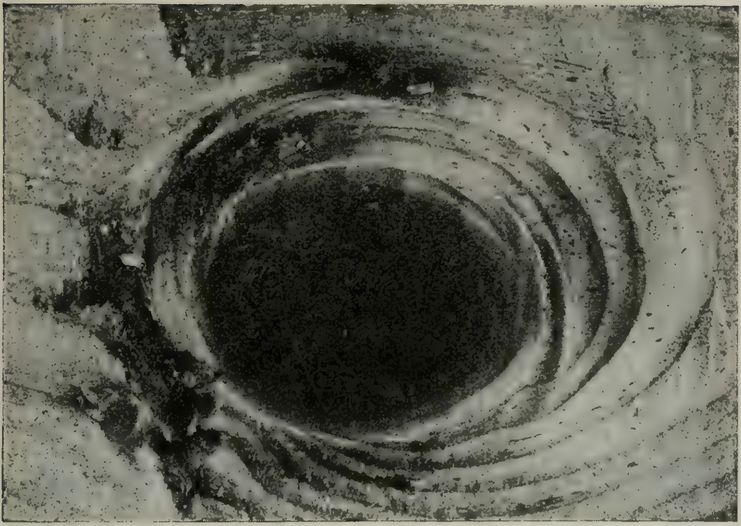
3. Recognized defects in Fir are knots, knotholes, splits, checks, wane, rot, rotten streaks, wormholes, dog or picaroon holes, pitch seams, shake, pitch pockets, chipped grain, torn grain, loose grain, solid pitch, stained heart, sap stain and imperfect manufacture.

KNOTS.

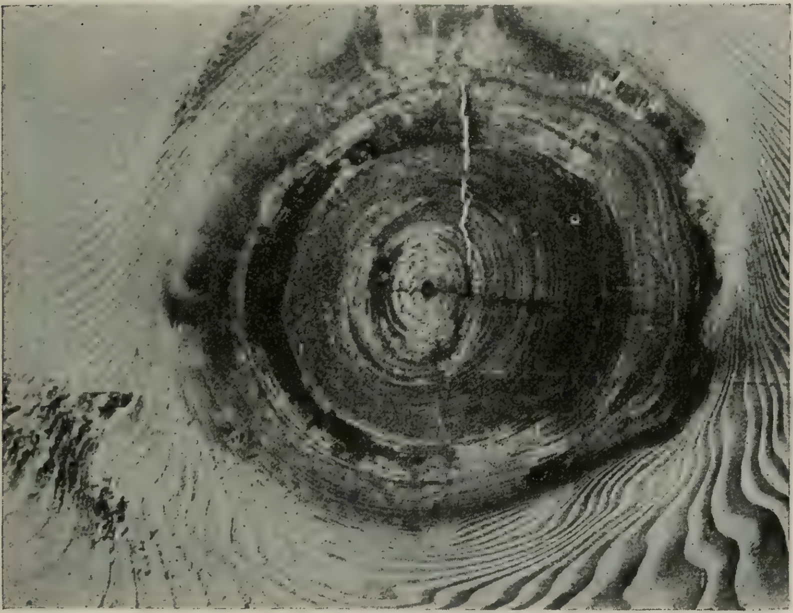
4. Knots shall be classified as pin, small, standard and large, as to size; round and spike as to form, and tight, loose and rotten as to quality.
5. A pin knot is tight and not over ½ in. in diameter.
6. A small knot is tight and not over ¾ in. in diameter.
7. A standard knot is tight and not over 1½ in. in diameter.
8. A large knot is tight, and any size over 1½ in. in diameter.
9. A round knot is oval or circular in form.
10. A spike knot is one sawn in a lengthwise direction.



Pin Knot.



Standard Knot.



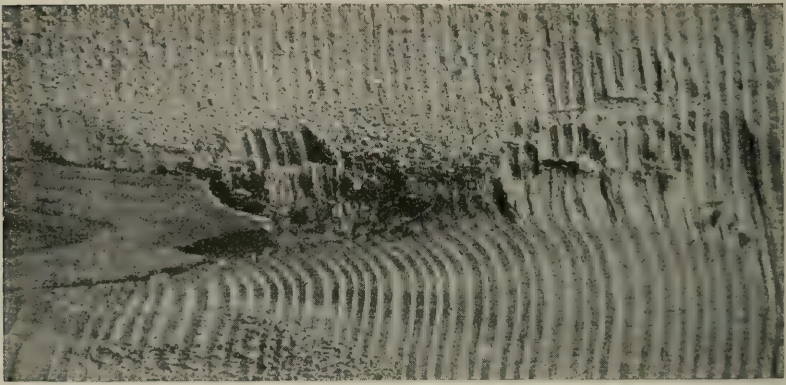
Large Knot.

The mean or average diameter of knots shall be considered in applying and construing the rules.

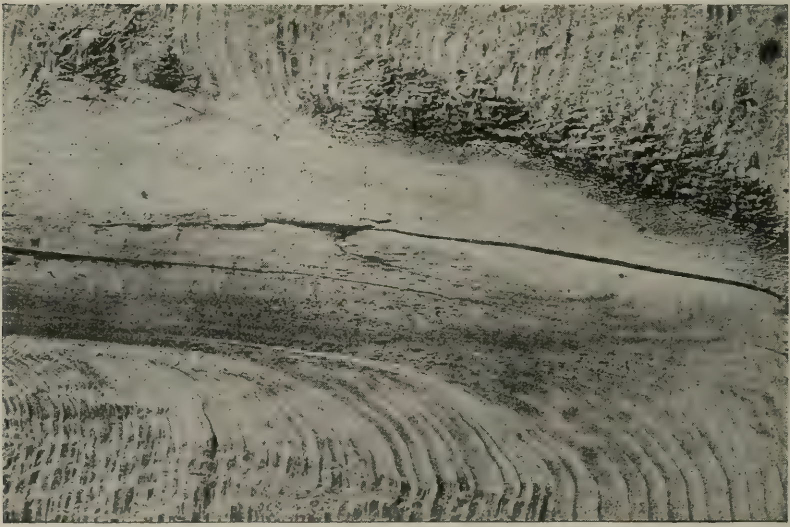
11. A tight knot or sound knot is one solid across its face, is as hard as the wood it is in, and is so fixed by growth or position that it will retain its place in the piece.

12. A loose knot is one not held firmly in place by growth or position.

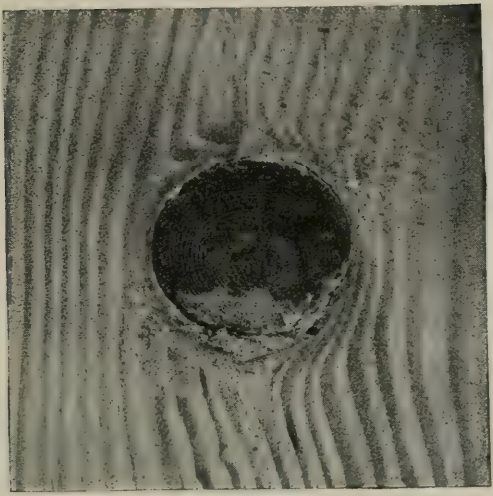
13. A rotten knot is one not as hard as the wood it is in.



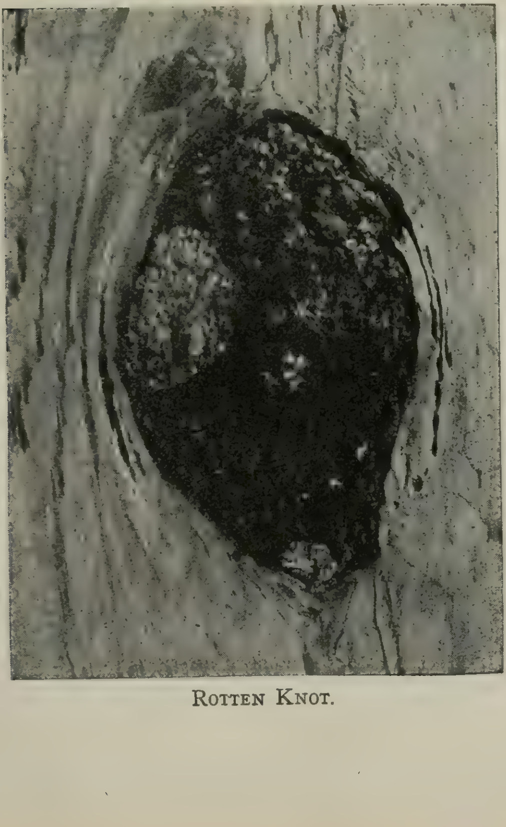
Small Spike Knot.



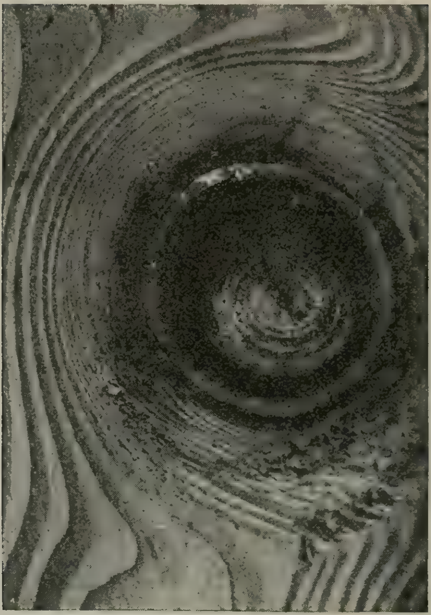
Large Spike Knot.



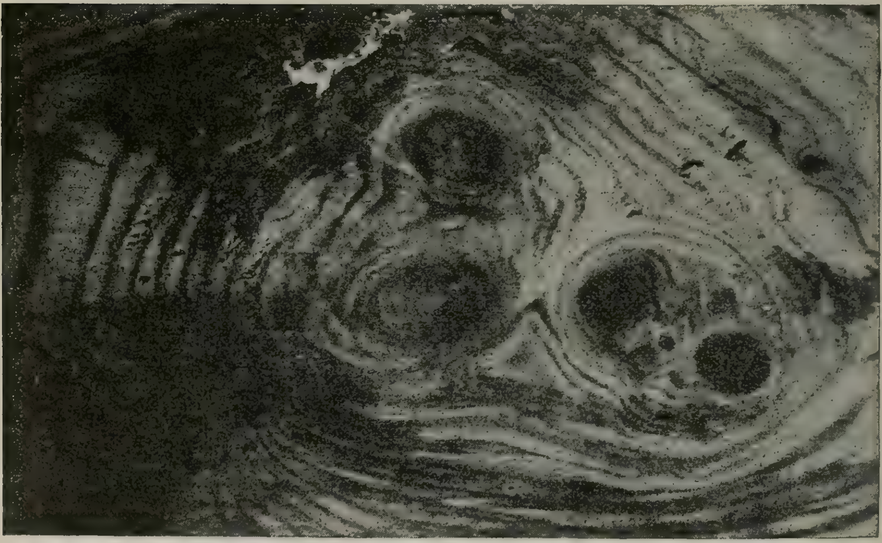
Loose Knot.



Rotten Knot.



Pith Knot.



Cluster of Knots.

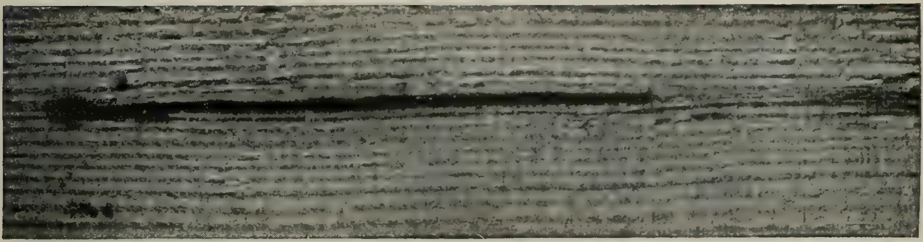
PITCH.

14. Pitch pockets are openings between the grain of the wood, containing more or less pitch and surrounded by sound grain wood; they shall be classified as small, standard and large pitch pockets.

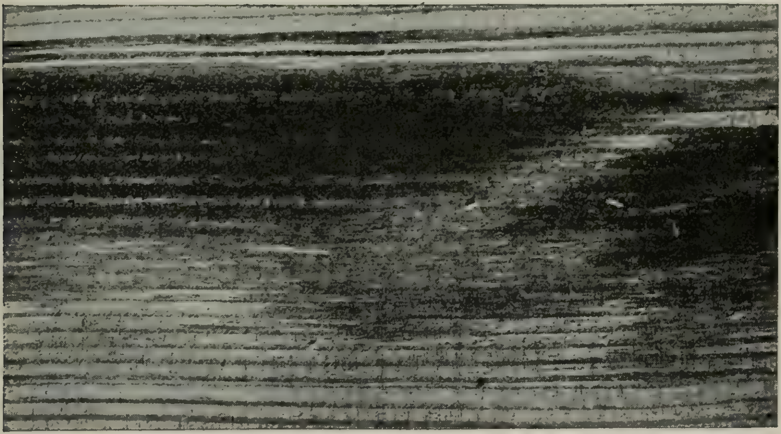
15. A small pitch pocket is one not over ⅛ of an in. wide.

16. A standard pitch pocked is one not over ⅜ of an in. wide or 3 in. in length.

17. A large pitch pocket is one over ⅜ of an in. wide or over 3 in. in length.



Closed Small Pitch Pocket.



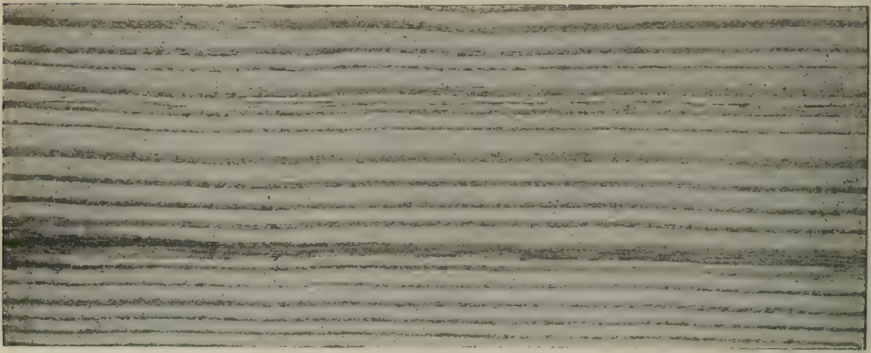
Solid Pitch.

18. A pitch shake or seam is a clearly defined opening between the grain of the wood and may be either filled with granulated pitch or not, but in either case is considered a defect in any of the grades hereinafter described.

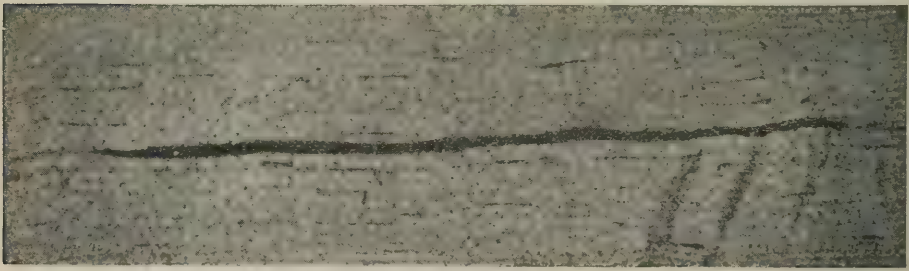
19. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch it shall not be considered a defect.

20. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

21. A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.



Small Pitch Streak.



Large Open Pitch Pocket.

WANE.

22. Wane is bark, or the lack of wood, from any cause, on edge.

SAP.

23. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

24. Sap stain shall not be considered a defect, except as provided herein.

25. Discoloration of the heart of the wood, or stained heart, must not be confounded with rot or rotten streaks. The presence of rot is indicated by a decided softness of the wood where it is discolored or by small white spots resembling pin wormholes.

MISCELLANEOUS.

26. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

27. All stock, except timbers, shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

28. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

29. Torn grain consists of a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters—slight, medium, heavy and deep.

30. Slight torn grain shall not exceed 1-32 of an in. in depth; medium 1-16 of an in., and heavy ⅛ of an in. Any torn grain heavier than ⅛ of an in. shall be termed deep.

31. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in flooring.

32. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* piece *such grades may contain,* but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

33. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

34. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

35. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

36. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

37. The term "Vertical Grain" is here used as synonymous with edge grain, rift-sawn, or quarter-sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

SPECIFICATIONS FOR DOUGLAS FIR STRUCTURAL TIMBERS.

GENERAL REQUIREMENTS.

38. All timbers shall be of live, sound, straight-grained timber, sawed square edges. When rough shall not be more than ¼ scant of actual size. Example: A piece of 12x12 shall not measure less than 11¾x11¾ in. When surfaced, ¼ in. shall be allowed for each face dressed. Example: A piece 12x12 shall measure not less than 11½x11½ in.

39. A reasonable variation from these rules shall be allowed where the general character of the piece shows its suitability for the purpose intended.

40. Select Stringers, either red or yellow fir, shall show not less than 80 per cent. of heart on each of the four sides, measured across the sides anywhere in the length of the piece; loose knots, or knot greater than 1½ in. in diameter, will not be permitted at points within 4 in. of the edges of the piece. Shall be free from shakes or splits.

41. Standard Stringers, either red or yellow fir or hemlock, will allow 1 in. wane on one corner—knots not to exceed, in their largest diameter, ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ the length of the piece are admissible.

42. Select Caps and Sills, either red or yellow fir, shall show 80 per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece; to be free from knots over 3 in. in diameter; knots must not be in groups. Free from shakes or splits.

43. Standard Caps or Sills, either red or yellow fir or hemlock, will allow 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed in the largest diameter ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ the length of the piece admissible.

44. Select Posts, either red or yellow fir, shall show not less than 75 per cent. heart, measured across the face anywhere in the length of the piece; to be free from knots over 3 in. in diameter, and must not be in groups. Shall be free from shakes or splits.

45. Standard Posts, either red or yellow fir or hemlock. Will allow 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed in their largest diameter ¼ of the width of the face of the stick in which they occur. Ring shakes shall not extend over ⅛ of the length of the piece.

46. Select Longitudinal Struts or Girts.—Either red or yellow fir shall show one face all heart; the other face and two edges shall show not less than 85 per cent. heart, measured across the face or edge anywhere in the length of the piece; to be free from knots over 1½ in. in diameter.

47. Standard Longitudinal Struts or Girts.—Either red or yellow fir or hemlock. Shall be square edged and sound; to be free from knots of 1½ in. in diameter or over.

48. Select Longitudinal X-Braces, Sash Braces and Sway Braces. Shall show not less than 80 per cent. heart on two faces and four square edges; to be free from knots over 1½ in. in diameter.

49. Standard Longitudinal X-Braces, Sash Braces and Sway Braces; shall be square edged and sound; to be free from knots over 2½ in. in diameter.

50. Select Ties and Guard Timbers.—Either red or yellow fir, shall show one face and one edge all heart; the other side and edge shall show not less than 75 per cent. heart, measured across the surface anywhere in the length of the piece. Shall be free from shakes or splits. Shall be free from black or rotten knots or sound knots over 2½ in. in diameter.

51. Howe Truss Chords.—Either red or yellow fir, shall show not less than 90 per cent. heart on each side and edge, measured anywhere in the length of the piece. Shall be free from shakes, splits or pitch pockets over ⅛ in. wide or 3 in. long. Knots shall be not over 1½ in. in diameter nor closer together on each surface than one in any four linear feet, but if knots are 1 in. or less in diameter, one in any three linear feet will be allowed.

52. Flooring or Decking.—Red or yellow fir or western hemlock shall be good sound common lumber. Will admit sound knots not over 1-3 the width of the piece. Spike knots not over 2-3 the width of the piece, wane not over ½ in. deep on edge and 1½ in. wide on face, extending not over ¼ the length of the piece; season checks, 2 or 3 grub wormholes, a limited number of pin wormholes; torn grain.

53. Piles.—Red or yellow fir, cut from straight, live, thrifty trees, free from rotten knots, shakes or splits.

54. Selected Sheet Piles.—Selected common, either red or yellow fir, must be square edged. Will admit any quantity of sound knots not over 1½ in. in diameter, or small pitch pockets not over 4 in. in length.

55. No. 1 Sheet Piles.—No. 1 common, either red or yellow fir or western hemlock, will admit of sound knots not over 1-3 the width of the piece. Spike knots not over 2-3 the width of the piece, wane not over ½ in. deep on edge and 1 in. wide on face up to 2x6, and ½ in. deep on edge and 1½ in. wide on face on 2x8 and wider, extending not over ¼ the length of the piece; stain, solid pitch, pitch pockets, season checks, 2 or 3 wormholes, a limited number of pin wormholes; torn grain.

BUILDING MATERIALS.

FLOORING.

Defects based on piece 4 in. wide, 12 ft. long, on all the following to and including Casing and Base, excepting where otherwise stated.

56. No. 1 Clear—Vertical grain, 3, 4 and 6 in. Shall be well milled on face, must have perfect edges and be practically free from all defects. Bright sap showing not more than one-third of face half the length of piece will be admitted. Angle of grain not less than 45 degrees.

57. No. 2 Clear—Vertical grain, 3, 4 and 6 in. Shall be well manufactured. Angle of grain not less than 45 degrees. Will admit of slight roughness in dressing, and from one to three small, close pitch pockets, or equivalent defects.

A piece 14 ft. or longer may have one defect located 6 ft. or more from end of the piece, which can be cut out by wasting not more than 1½ in. in the length of the piece, provided balance of piece be practically free from other defects.

58. No. 3 Clear—Vertical grain, 3, 4 and 6 in. Angle of grain not less than 45 degrees. Will admit of roughness in dressing; two or three small lots not over ¾ in. in diameter, or eight small pitch pockets, any three of which may be open. It is generally understood that this grade will admit such defects or combination of defects as will not impair its utility for cheap floors.

A piece otherwise as good as No. 2, may have a defect that can be cut out and the piece laid with a loss of not more than 2½ in. in length, providing the defect is 4 ft. or more from the end of the piece.

59. No. 2 Clear and Better—Flat grain, 3, 4 and 6 in. Shall be well manufactured; will admit of slight roughness in dressing. Either of the following also permitted with the above. Three close pitch pockets, not to exceed 2 in. each in length; three small, tight, smooth knots ½ in. in diameter, or their equivalent of combined defects.

A piece 14 ft. or longer may have one defect, located 6 ft. or more from the end of the piece, that can be cut out by wasting not more than 1½ in. of the length of the piece, provided balance of piece be practically free from other defects.

60. No. 3 Clear—Flat grain, 3, 4 and 6 in. Will admit of roughness in dressing; four small knots not over ¾ in. in diameter, or eight small pitch pockets, any three of which may be open, or without the above defects, three knots not over 1 in. in diameter, or the equivalent of combined defects.

A piece of otherwise as good as No. 2, can have a defect that can be cut out and the piece laid with a waste of not more than 2½ in. in its length, providing the defect is 4 ft. or more from the end of the piece.

Vertical grain pieces that are a little below the line of No. 3 vertical grain will be admitted in this grade.

It is generally understood that this grade will admit such other defects or combinations of defects as will not impair its utility for cheap floors and sheathing.

CEILING.

61. No. 2 Clear and Better—3, 4 or 6 in. Shall be well manufactured. Will admit of slight roughness in dressing. Either of the following also permitted with the above: Three close pitch pockets, not to exceed 2 in. each in length; three small, tight, smooth knots ½ in. in diameter, or their equivalent in combined defects. Both Vertical and Flat grain admissible.

A piece 14 ft. or longer may have a defect located 6 ft. or more from the end of the piece that can be cut out by wasting not more than 1½ in. in the length of the piece, provided balance of piece be practically free from other defcts.

62. No. 3 Clear—3, 4 or 6 in. Allows any three of the following defects: Twenty-five per cent. of the face may be rough from dressing. Four-in. stock admits of not to exceed six tight knots ¾ in. in diameter, or two knots 1 in. in diameter, or three open pitch pockets not to exceed 4 in. each in length, or an equivalent number of tight pitch pockets. Six-in. is correspondingly graded, with proportionately greater defects. Both Vertical and Flat grain admissible.

A piece otherwise as good as No. 2, may have a defect that can be cut out without wasting more than 2½ in. in length of the piece, providing it is more than 4 ft. from the end.

PARTITION.

63. 4 or 6 in. Shall be graded same as Ceiling on one face side, with the reverse side not more than one grade lower.

PORCH DECKING, DROP SIDING AND RUSTIC.

64. No. 2 Clear and Better—4, 6 and 8 in. Defects based on piece 6 in. wide, 12 ft. long. Shall be well manufactured. Slight roughness in dressing admissible; will allow three small, tight knots not more than ½ in. in diameter, or four tight pitch pockets, or their equivalent of combined defects.

A piece 14 ft. or longer may have one defect, located 6 ft. or more from the end of the piece, that can be cut out by wasting not more than 1½ in. in the length of the piece, provided balance of piece be practically free from other defects.

65. No. 3 Clear—4, 6 and 8 in. Will admit of roughness in dressing; four or five knots not larger than 1 in. in diameter, or eight small pitch pockets, any three of which may be open, or their equivalent of combined defects.

A piece that is otherwise as good as No. 2, may have a defect that can be cut out by wasting not more than 2½ in. in the length of the piece, providing that it is more than 4 ft. from the end of the piece.

BEVEL SIDING.

66. No. 2 Clear and Better—4, 5 and 6 in. Will admit of slight defects in dressing or two close pitch pockets or other minor defects, but each piece shall be suitable for use the full length without waste.

67. No. 3 Clear—4, 5 and 6 in. Will admit of small, sound knots, small pitch pockets, roughness in dressing or other recognized defects, but not to exceed four of any of the said defects or their equivalent in any one piece.

STEPPING.

68. No. 2 Clear and Better—8 to 14 in. Shall be well manufactured. Will allow chipped grain or slight torn grain on face and nosed edge, six close pitch pockets. With one of the above defects may have from one to three spike knots that do not show more than 2-in. on riser edge of the face side, or flat grain ¼ of the face on the riser edge, or one small pitch pocket.

FIR.

69. No. 3 Clear—Will admit of medium torn grain, heavy torn grain or loose grain in two or three places; season checks that do not go through; stain covering one-fourth of the face of the piece. With any one of the above, one of the following or their equivalent of combined defects will be allowed; eight small pitch pockets or their equivalent of larger pockets; wane ½-in. deep on back edge, ½-in. wide on face; one standard pitch streak; six small knots; three 1-in. knots, or their equivalent of pin knots; two dog holes that do not go through; six picaroon or grubworm holes.

FINISH.

70. Selected Grain—1, 1¼, 1½ and 2 in. thick, 4 to 12 in. wide. Shall be free from sap and all defects on face and edges, and selected for beauty and character of grain.

71. No. 2 Clear and Better—1, 1¼, 1½ and 2 in. thick, 4 to 12 in. wide. Based on 1x8-12. Rules to apply proportionately on narrower and wider stock. Will allow one straight split not exceeding the width of the piece; slight torn grain on face and edges; medium torn grain in one or two curly places; a small amount of stain. In addition to one of the above one of the following will be allowed: Three tight, smooth pin knots; one tight, smooth, small knot; three to five tight pitch pockets that do not go through the piece; one small pitch streak; three picaroon holes not more than ¼ in. in diameter; two or three small kiln or seasoning checks or their equivalent of combined defects.

It is understood that this grade shall present a smooth surface after painting.

A piece 14 ft. long or longer may have a defect located 4 ft. or more from the end that can be cut out by wasting not more than 1½ in. in the length of the piece; provided balance of piece be practically free from defects.

72. No. 3 Clear—1, 1¼, 1½ and 2 in. thick, 4 to 12 in. wide. Based on 1x8-12. Rules to apply proportionately on narrower and wider stock. Will admit of medium torn grain, heavy torn grain or loose grain in two or three places; season checks that do not go through stain covering one-fourth of the face of the piece. With any one of the above, one of the

following or their equivalent of combined defects will be allowed. Eight small pitch pockets or their equivalent of larger pockets; wane ½ in. deep on edge, ½ in. wide on face; one standard pitch streak; six small knots; three 1-in. knots, or their equivalent of pin knots; two dogholes that do not go through; six picaroon or grubworm holes.

CASING AND BASE.

73. To be graded same as Finish.

TANK STOCK.

74. Must be water tight the full length of the piece, unless it is for cutting stock. Small knots, or pitch pockets which do not go through the piece, not to be considered defects. Edges to be practically clear or to contain no defects that will prevent a water-tight joint when worked.

Two-inch stock to contain practically no sap, 3-in. stock, when 12 in. wide, to allow 3 in. of sap on both edges of face side, not to extend over ¾ in. through the piece. Can be either vertical or slash grain.

TURNED PORCH COLUMNS.

75. No. 1 Columns to grade 80 per cent. Clear; the balance of 20 per cent. to admit of the following slight defects: Three small sound knots not over ¾ in. in diameter on the smooth part of the turned shaft, or on the square, or three tight pitch pockets, to be not over 3 in. long, or the equivalent in both knots and pitch pockets. Bright sap shall be no defect. The 5x5 and the 6x6 shall be bored through with not less than 1¾-in. bit.

The 4x4 to be bored through the square ends. The Colonial Columns shall be bored through with not less than a 2-in. bit.

Boring to be at the option of the manufacturer.

FENCING.

76. Common Fencing must be manufactured from sound stock; may contain sound knots equal in diameter to not over one-third of the width of the piece, or spike knots the length of which is not over one-half of the width of the piece. May have wane ¼ in. deep on edge; not over 1 in. on face and one-quarter the length of the piece; torn grain; solid pitch; pitch pockets; stain, seasoning checks and a limited number of wormholes well scattered.

77. One-inch Selected Common—4 to 12 in. Shall be square edged. Will admit sound knots not over 1 in. in diameter in 4 in. and 6 in., and not over 1½ in. in 8 in. to 12 in., but located away from the edge; medium sized pitch pockets and slight stain. But should be of a sound, strong character.

BOARDS AND SHIPLAP AND D. & M.

78. Common. Will admit of any two of the following, or their equivalent of combined defects: Wane ½ in. deep on edge, 1 in. wide on face, extending not over one-sixth of the length of the piece; knots not more than one-third of the width of the piece in diameter; stain; torn grain; pitch streaks; pitch pockets; seasoning checks; one straight split not

longer than the width of the piece or a limited number of wormholes well scattered. These boards should be firm and sound and suitable for use in ordinary construction without waste.

79. No. 3 Common Boards or Sheathing. Will admit of all stock below the grade of Common that is suitable for cheap sheathing and will allow: Coarse knots; knotholes; splits; rotten streaks; rotten sap, and any number of grub or pinworm holes.

COMMON JOIST AND SCANTLING.

80. No. 1 Common. Generally speaking, this stock must be suitable and of sufficient strength for all ordinary construction purposes without waste. Will admit of coarser knots than 1-in. Common, which in a 2x4 should not be larger than 2 in. Spike knots not over two-thirds the width of the piece, wane not over ½ in. deep on edges and 1 in. wide on face, up to 2x6, and ½ in. deep on edge and 1½ in. wide on face on 2x8 and wider, extending not more than one-quarter the length of the piece; stain, solid pitch, pitch pockets, season checks, one straight split not more than the width of the piece, 2 or 3 grubworm holes, a limited number of pinworm holes and torn grain.

81. No. 2 Common. This grade must be suitable for use without waste in a cheaper class of construction than common. Will allow coarse and unsound knots and knotholes that do not unfit the piece for use intended, rotten streaks, pitch seams, pitch pockets, a reasonable amount of rotten sap and pinworm holes, a few grubworm holes well scattered It is understood that no culls or stock that will not work without waste will be allowed in this grade.

COMMON TIMBERS.

82. No. 1 Common. Rough timbers, 4x4 and larger, shall not be more than ¼ in. scant when green, and be evenly manufactured from sound stock, and must be free from knots that will materially weaken the piece.

Timbers 10x10 in size may have a 2-in. wane on one corner, or its equivalent on two or more corners, one-fourth the length of the piece. Other sizes may have proportionate defects. Season checks and checks extending not over one-eighth the length of the piece admissible.

83. No. 2 Common Timber. This is a grade of timber that will admit of large, loose or rotten knots, shakes or rot that do not impair its utility for temporary work. Hemlock and white fir will not be allowed in this grade.

SELECTED COMMON.

84. 2x4 to 2x12 and 3x4 to 4x6 shall be square edged. Will admit any quantity of sound knots, not over 1 in. in diameter, or small pitch pockets not over 4 in. in length. Sizes larger than 4x6 will admit sound knots not to exceed 1½ in. in diameter; pitch pockets not to exceed 6 in. in length.

It is understood that this is Selected Common, a grade lower than No. 3 Clear, and not to be confused with it.

STANDARD SIZES.

92. In the absence of a special agreement between the buyer and seller for each order, all dressed lumber is finished to the following sizes:

Flooring.

1 x3.......................Finished Size 13/16x2¼ face
1 x4.......................Finished Size 13/16x3¼ face
1 x6.......................Finished Size 13/16x5⅛ face
1¼x4.......................Finished Size 1 1/16x3¼ face
1¼x6.......................Finished Size 1 1/16x5⅛ face

Ceiling.

⅜x4.......................Finished Size 5/16x3¼ face
⅜x6.......................Finished Size 5/16x5⅛ face
½x4.......................Finished Size 7/16x3¼ face
½x6.......................Finished Size 7/16x5⅛ face
⅝x4.......................Finished Size 9/16x3¼ face
⅝x6.......................Finished Size 9/16x5⅛ face
1 x4.......................Finished Size 11/16x3¼ face
1 x6.......................Finished Size 11/16x5⅛ face

Partition.

1 x4.......................Finished Size ¾x3¼ face
1 x6.......................Finished Size ¾x5⅛ face

Shiplap and D. & M.

1 x8.......................Finished Size ¾x7 face
1 x10.......................Finished Size ¾x9 face
1 x12.......................Finished Size ¾x11 face

Drop Siding.

1 x4.......................Finished Size ¾x3¼ face
1 x6.......................Finished Size ¾x5⅛ face
1 x8.......................Finished size ¾x7 face

Rustic.

1 x6......Channel, Finished Size ¾x4⅞, ½ in. Rabbet
1 x8......Channel, Finished Size ¾x6¾ ½ in. Rabbet
1 x6...........V. Finished Size ¾x4⅞ ½ in. Rabbet
1 x8...........V. Finished Size ¾x6¾ ½ in. Rabbet

For further particulars see diagrams of standard patterns.

Dimension, S1S1E or S4S—

2x 4 to 1⅝x 3⅝
2x 6 to 1⅝x 5⅝
2x 8 to 1⅝x 7½
2x10 to 1⅝x 9½
2x12 to 1⅝x11½

3x 6 to 2½x 5½
3x 8 to 2½x 7½
3x10 to 2½x 9½
3x12 to 2½x11½

Timbers, S1S1E or S4S—

4x4 and larger, ½ in. off each way.

Finishing, Thickness S1S or S2S—

1 in. to ¾
1¼ in. to 1 1/16
1½ in. to 1 5/16
2 in. to 1¾

Widths, if Dressed on One or Both Edges—

4 in. to 3½ in.
5 in. to 4½ in.
6 in. to 5½ in.
8 in. to 7¼ in.
10 in. to 9¼ in.
12 in. to 11¼ in.
14 in. to 13 in.
16 in. to 15 in.

Common Boards and Sheathing—

S1S or S2S to ¾ in.

Grooved Roofing—

¾ in.x7¼, 9¼, 11 1-4 in. face ½ in. Groove 1½ in. from each edge.

Bevel Siding—

6 in.—3/16 in. thin edge. ½ in. thick edge. 5½ in. wide. 4 in.—Same thickness, 3½ inches wide.

Pickets—

1¼ in. square, 1 1-16x1 1-16 in. S4S
1½ in. square, 1 5-16x1 5-16 in. S4S
1x3 flat, ¾x2¼ in. S4S

Standard Lath—

1-3 in. x 1 1-2 x 4 ft.

BATTENS.

Are usually made of edgings of good, sound stock and worked to the following sizes:

3 in. Flat to 5/16x2½ in.
2 in. O. G. to ¾x1¾ in.
2½ in. O. G. to ¾x2¼ in.
3 in. O. G. to ¾x2½ in.

Appendix B.

CLASSIFICATION, GRADING AND DRESSING RULES FOR NORTHERN PINE, INCLUDING WHITE AND NORWAY PINE AND HEMLOCK.

1. Norway Pine. To cover Norway or Red Pine grown in Michigan, Minnesota, Wisconsin and Canada.

White Pine to cover wood from tree of that name grown in Maine, Michigan, Wisconsin, Minnesota and Canada.

2. Northern Pine Lumber shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, except where otherwise expressly stipulated between buyer and seller.

3. Recognized defects in Northern Pine are knots, knotholes, splits, shake, wane, wormholes, pitch pockets, torn grain, loosened grain, sap, sap stain, checks and rot.

KNOTS.

4. Knots shall be classified as pin, small and large or coarse, as to size, and round or spike, as to form, and as sound, loose, encased, pith and rotten, as to quality.

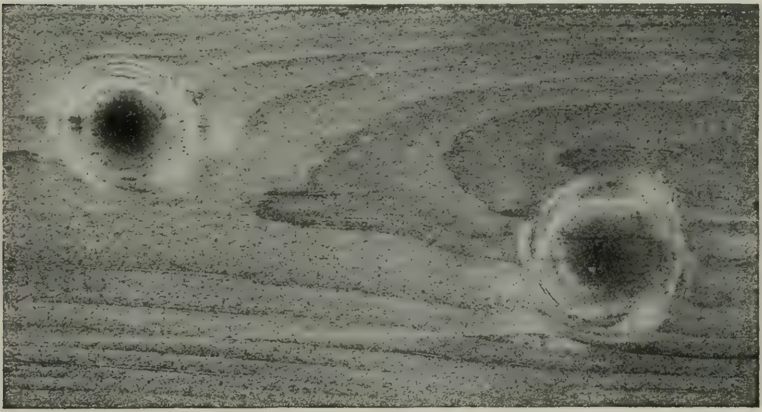
5. A pin knot is sound and shall not exceed ½ in. in diameter.

6. A small knot is larger than a pin knot and shall not exceed 1½ in. in diameter.

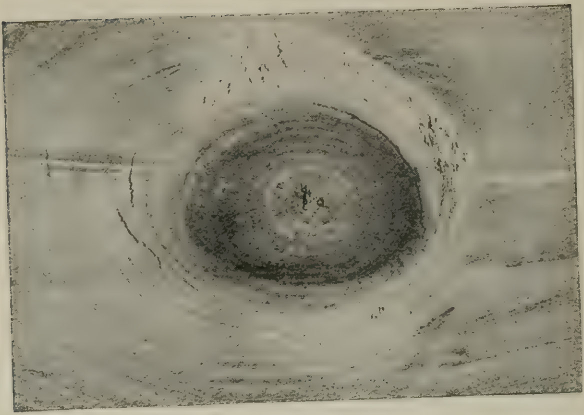
7. A large or coarse knot is one of any size over 1½ in. in diameter.

8. A round knot is oval or circular in form.

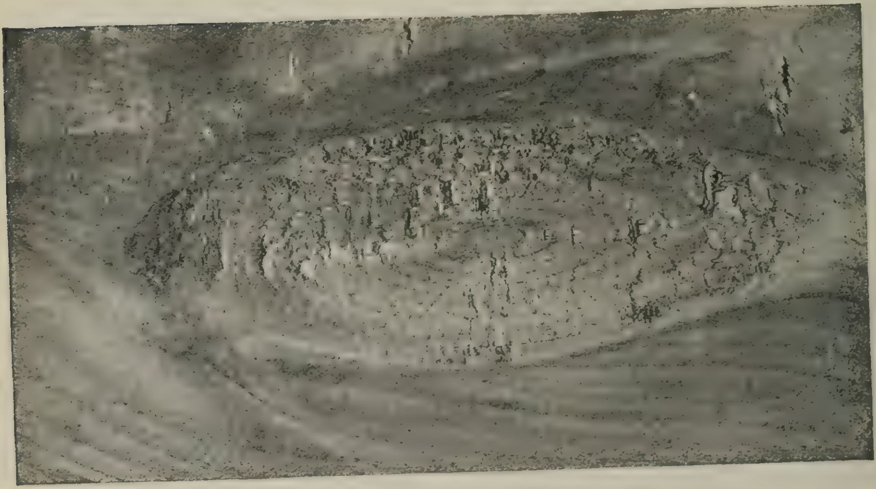
9. A spike knot is one sawn in a lengthwise direction.



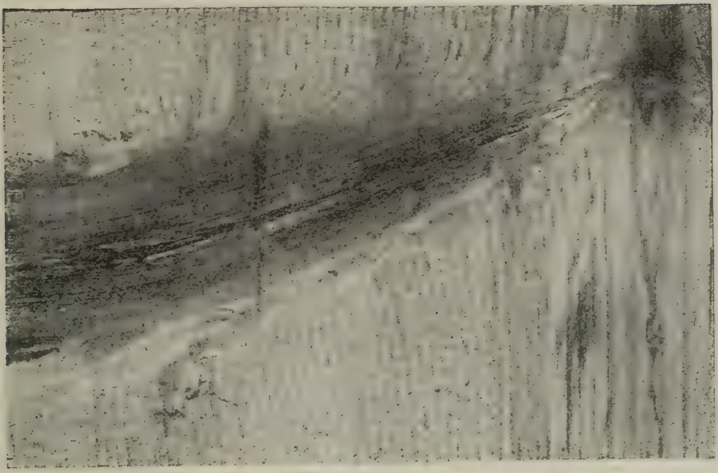
PIN KNOTS.



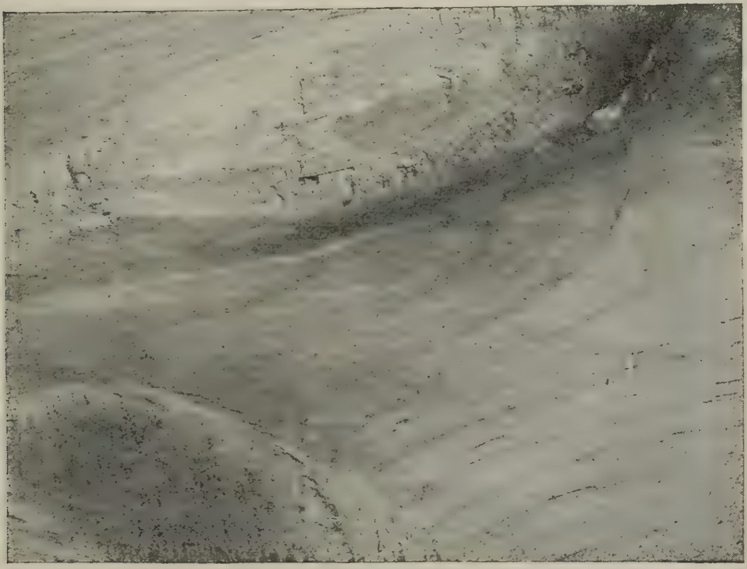
Small and Round Pocket.



Large Knot.



Spike Knot.



Sound Knots.

The mean or average diameter of knots shall be considered in applying and construing these rules.

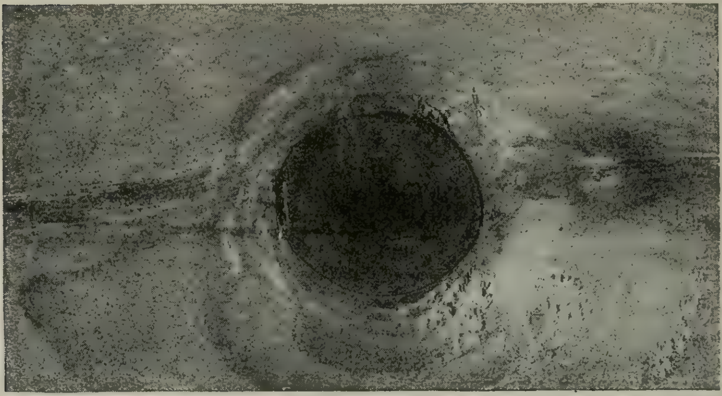
10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is not firmly set, but still retains its place in the piece.

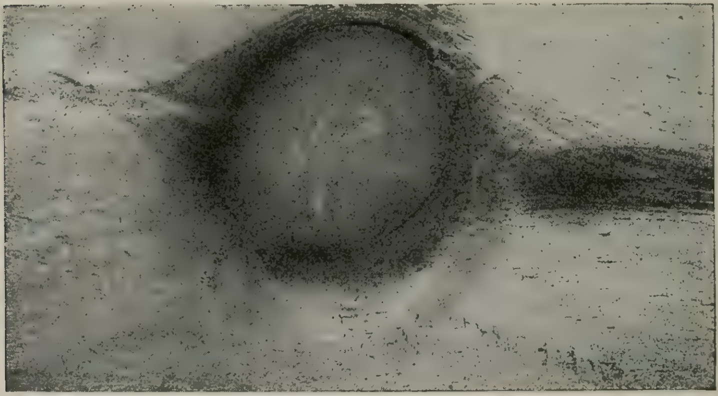
12. A pith knot is a sound knot with a pith hole not more than ¼ in. in diameter.

13. An encased knot is one surrounded wholly by bark or pitch.

14. A rotten knot is one not as hard as the wood it is in.



Loose Knot.



Encased Knot.

PITCH.

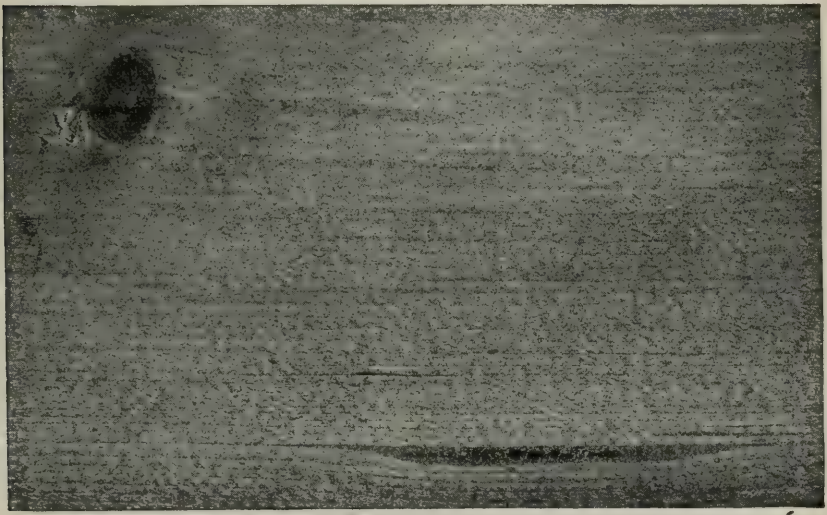
15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an in. wide.

17. A standard pitch pocket is one not over ⅜ of an in. wide, or 3 in. in length.

18. A large pitch pocket is one over ⅜ of an in. wide or over 3 in. in length.

19. A pitch pocket showing open on both sides of the piece ⅛ of an in. or more in width shall be considered the same as a knothole.



Small Pitch Pocket.

WANE.

20. Wane is bark, or the lack of wood, from any cause, on edge.

SAP.

21. White or bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

MISCELLANEOUS.

22. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

23. All lumber for uses described in these rules shall be inspected on the face side to determine the grade, and the face side is the side showing the best quality or appearance.

24. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as torn grain, and shall not be considered a defect.

25. Torn grain consists in a part of the wood being torn out in the dressing. It occurs around knots and curly places, and is of four distinct characters: slight, medium, heavy and deep.

Slight torn grain shall not exceed 1-32 of an in. in depth, medium 1-16 of an in., and heavy ⅛ of an in. Any torn grain heavier than ⅛ of an in. shall be termed deep.

26. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest pieces such grades may contain, but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

27. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

28. All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.

29. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or mill work will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

BRIDGE AND TRESTLE TIMBERS.

No specifications for White Pine, Norway Pine and Hemlock have been framed, pending action by the Committee on Wooden Bridges and Trestles.

NORTHERN PINE BUILDING LUMBER.

FINISHING.

Clears.

31. First Clear.—This should be twelve inches or wider and free from all defects.

32. Second Clear.—This should be ten inches or wider. When ten inches wide it should be free from all defects. A twelve-inch board must have a perfect face. A half-inch of white sap on each edge, or one in. of sap on one edge of back is allowed. In the absence of sap one or two small pin knots not to exceed one-half in. in diameter are admissible. Pieces wider than twelve in. must have a perfect face but can have sap or knot defects proportionally greater as the piece is wider.

33. Third Clear.—This should be eight inches or wider. A piece eight inches wide should be free from all defects on both faces. In a ten-inch piece one or two small knots, not to exceed one-half inch in diameter, or in the absence of knots, white sap not to exceed one-half in. in width on each edge, or one in. in width on one edge is admissible. A

piece from twelve inches to fourteen inches wide may have one in. of white sap on each edge of face or more sap on one edge. In the absence of sap or with less sap one or two small knots an inch in diameter are admissible. Wider stock can have more sap or slightly larger knots. The reverse side of Third Clear ten inches and wider should not show poorer in quality than "A" Select face.

"A" Select.

34. "A" Select should be eight inches or wider. On the face side an eight-in. piece should be nearly perfect. An in. of white sap on one edge or one or two sound knots not to exceed one-half in. in diameter are admissible.

35. A ten-inch piece will admit of an inch and a half of white sap full length of one edge or less sap on both edges of face with no other defects, or will admit of two or three knots one-half in. in diameter if well scattered, or one or two knots not over an inch in diameter if well located.

36. Pieces fourteen inches and wider will admit of proportionately greater sap and knot defects as width increases, or very slightly local shake, or a straight split for six or eight inches, or one or two large worm holes near end or edge.

"B" Select.

37. "B" Select should be 8 in. or wider.

38. In this grade white sap is not considered a defect unless too many other imperfections appear.

39. Knots, shake and a small amount of stained sap are admissible.

40. An eight-in. or ten-in. piece should have but very little shake. Wider pieces can have more shake, but it should be local and not scattered over the face of the piece.

41. Slightly stained sap is admissible when other defects are not of a serious nature, the amount of stained sap depending upon width of piece.

"C" Select.

42. "C" Select must be eight inches or wider.

43. This grade will admit of quite serious defects if the piece retains at the same time a fair appearance.

44. The defects admissible are the same as those in "B" Select, but exist to a greater degree.

"D" Select.

45. "D" Select should be 8 inches or wider.

46. This grade admits any piece of lumber that has the appearance of finishing or a percentage of cutting in which the defects are too numerous or too serious to admit of its being graded into "C" Select.

47. Blue sap covering two-thirds of the face will be admitted. This description embraces one in., one and one-fourth in., one and one-half in. and two in. stock and is graded strictly from the face without regard to the back and cannot be recommended for quality.

"D" Stock and Box.

48. This is a grade of smooth-looking and sound-knotted lumber with edges free from wane and the grade practically free from shake.

49. The knots may be either black or red, but should be sound and firmly set, varying in size from an inch and a half down.

50. A "D" Box Board may have any number of sound knots, depending entirely upon their size and location.

51. A 12-in. "D" Stock board should contain a less number of knots than a "D" Box, and 8 and 10-in. "D" Stock boards relatively smaller knots and less in number. This grade is nothing more than an extra smooth No. 1 Common.

"C" and Better Norway.

52. C and Better Norway shall be 4 inches or wider and of the same thickness as white pine.

53. White sap is no defect, and one-fifth the surface of the face may be covered with sound, stained sap, if not in combination with other defects.

54. This grade should be practically free from shake, rot and splits.

55. The knotty and wane defects in the low line pieces of this grade should be the same as in the grades of white pine B Strips and B Selects.

56. All knots to be sound and firmly set. The product of the log better than described above is included in this grade.

SIDING.

General Instructions.

57. Beveled Siding should be graded from the face side only.

58. Defects on the thin edge which will cover when laid should not be given the same consideration as defects elsewhere.

"A" and Clear Siding.

59. "A" and Clear Siding will admit of bright sap on thin edge which will cover when laid, or a half-inch of bright sap on thick edge for one to two feet, or in the absence of sap one or two pin knots.

"B" Siding.

60. "B" Siding will admit of any amount of white sap, or two or three sound knots not to exceed one-half inch in diameter, well scattered over the face of the piece.

"C" Siding.

61. "C" Siding will admit of any amount of bright sap.

62. When sap defect is not too pronounced, two or three small knots, not exceeding one inch in diameter, or more knots when smaller, or slight shake are admissible.

63. A small amount of slightly blue sap on the thick edge is admissible, or more blue sap on the thin edge.

64. Defects requiring one cut not to exceed four in. of waste are allowed in high line pieces twelve ft. long and longer.

"D" Siding.

65. "D" Siding will admit of considerable shake and stained sap. With or without either of these defects a piece may have a number of small knots well scattered over the face.

"E" Siding.

66. This is the lowest recognized grade of Beveled Siding and will admit of the sap, knot and shake defects not admissible in "D" Siding.

67. Many pieces showing seriously defective mill work are found in this grade.

FLOORING.

"A" Flooring.

68. "A" Flooring is a one-faced strip and should lay with a practically clear face.

69. A half in. of bright sap, or one or two small pin knots are admissible in this grade.

"B" Flooring.

70. "B" Flooring will admit of any amount of white sap, or two or three knots from a quarter to half an inch in diameter.

"C" Flooring.

71. "C" Flooring will admit of bright sap face or two knots one in. in diameter, or three to five knots one-half in. or less in diameter, but not a combination of these defects unless of a decidedly less amount, and must be practically free from shake.

"D" Flooring.

72. "D" Flooring is a grade between No. 1 Fencing D & M and "C" Flooring, and will admit in a general way the imperfections of both grades.

73. In a knotty type the knots must be smaller and fewer in number than in No. 1 Fencing, and may be either red or black.

74. Some stained sap is allowed and tight local shake.

75. Defects requiring one cut, not to exceed four inches of waste, are allowed in high line pieces 12 feet long and longer.

Farmers' Clear Flooring.

76. Farmers' Clear Flooring is of a practically clear appearance.

77. The knotty defects shall not exceed that of a "C" Flooring.

78. The leading defect is shake, which may be scattered over the face of the strip.

No. 1 Fencing D & M.

79. This should be simply sound No. 1 Fencing worked to flooring, and of the character, when worked, described under the title of No. 1 Common Strips.

No. 2 Fencing D & M.

80. This should be simply No. 2 Fencing worked to flooring, and of the character, when worked, described under the title of No. 2 Common strips.

No. 3 Fencing D & M.

81. No. 3 Fencing D & M is the regular grade of No. 3 Fencing worked to flooring and may contain coarse knots, an occasional knot hole, splits, wane, worm holes, streaks of red rot, and a great deal of shake, but not a serious combination of these defects.

Common Lumber.

82. Common lumber may consist of white or Norway pine, or a mixture of both.

83. The characteristic of Common lumber, as distinguished from Finishing, consists of a general coarseness of appearance, caused by various defects and combinations of defects, in a greater or less degree according to the grade.

No. 1 Common Boards and Strips.

84. No. 1 Common Boards and Strips includes all sound, tight-knotted stock, whether red or black knots, free from very large coarse knots, or any imperfections that will weaken the piece.

85. This grade should be of a character fitting it for ordinary use, except finishing purposes.

86. Knots, medium colored blue sap, or a small amount of shake are admissible if they do not affect the general utility of the piece.

87. Norway Boards and Strips, except Clear and Select, should not be put higher than No. 1 Common. The class of Norway admissible in this grade can contain either black or red knots, provided they are small and firmly set, or medium colored blue sap covering the entire piece.

No. 2 Common Boards and Strips.

88. No. 2 Boards and Strips are subject to the same general inspection as No. 1, except that coarser and larger knots, not necessarily sound, more stained sap and shake are allowed. "V" and coarse limb knots, heart shake or slight trace of rot, when firm, or occasional worm holes, are defects admissible in this grade.

89. Norway, with stained sap covering the entire face of the piece, is admissible if not in combination with other marked defects.

No. 3 Common Boards and Strips.

90. The general appearance of this grade of lumber is coarse, admitting:

91. Large loose or unsound knots.
92. An occasional knot hole.
93. A great deal of shake.
94. Some red rot.
95. Large worm holes.
96. Any amount of blue sap.
97. Not a serious combination of these defects in any one piece is admissible.

No. 4 Boards and Strips.

98. The predominating defect characterizing this grade is red rot.

99. Other types are pieces showing numerous large worm holes, or several knot holes, or pieces that are extremely coarse knotted, waney, shaky or badly split.

100. Norway, when extremely cross checked, is admissible in this grade.

No. 5 Boards.

101. No. 5 Boards is the lowest recognized grade and admits of all defects known in lumber, provided the piece is strong enough to hold together when carefully handled.

JOISTS, SCANTLING AND TIMBER.

No. 1.

102. No. 1 joists and scantling must be of a good, sound character, but will admit of defects that do not impair the strength of the piece.

103. On basis of 2x4, wane on edge is admissible, one-half in. deep, for half the length, or a proportionate amount for a shorter distance or on both edges. In any case, one side and two edges should allow a good nailing surface, it being understood, however, that the wane shall in no case extend over one-half the side of the piece.

104. A few worm holes admissible.

105. Stained sap is not considered a defect.

106. Timbers and 3-in. plank admit proportionately greater defects.

107. Two-in. dimension of this grade may contain 20 per cent. of No. 1 tamarack, and 3-in. and thicker and timbers may contain any amount of No. 1 tamarack.

No. 2.

108. No. 2 will admit of large, coarse knots, not necessarily sound, considerable wane, also shake, worm holes, red, dozy streaks; crooked pieces or other defects which weaken or impair the pieces to such an extent as to render it unfit for No. 1 grade.

109. Any amount of No. 2 tamarack is admissible in this grade.

No. 3.

110. No. 3 will admit a great deal of rot and all the imperfections allowed in No. 1 and No. 2, but in a much more pronounced form, and any amount of No. 3 tamarack.

HEMLOCK BUILDING LUMBER.

BOARDS AND STRIPS.

111. There are five grades made in Boards and Strips.
Inch Clear and Select.
Inch D Stock.
No. 1, or Common.
No. 2, or Sheathing.
No. 3, or Cull.

Inch Clear and Select.

112. Inch Clear and Select should be four in. and wider, and eight ft. long and longer, not to exceed ten per cent. eight ft. long.

113. This grade is especially adapted for interior finish and only the face, or best side, is expected to show, although some attention should be given to the back of the piece.

114. The face shall show no wane, but the back may show such an amount of wane or other defects as will not interfere with the use of the piece for finishing purposes.

115. No shake or season check shall be allowed on the face side, but a very little tight shake and checks that are not deep may appear on the back of the piece.

116. This grade will admit on the face side of several tight pin knots not over three-eighths of an inch in diameter. In a four or six-inch twelve feet and longer piece, not more than three knots are admissible, and proportionately more in a wider piece.

117. A ten or twelve-inch piece twelve feet and longer will not admit of more than three sound, firmly set knots, not to exceed three-fourths of an in. in diameter. Narrower and shorter pieces will admit of fewer large knots, but not a combination of large knots and other defects.

118. Pieces twelve feet and longer are admissible that will, with not more than ten per cent. of waste, produce two clear cuts each four feet long or longer.

Inch D Stock.

119. Inch D Stock shall consist of Boards and Strips below the grade of Clear and Select, four inches and wider, and eight feet long and longer, not to exceed ten per cent. eight feet long, and must be of a sound and watertight character.

120. All knots must be sound and firmly set. Red knots must not exceed one and one-fourth of an in. in diameter, and spike knots must not exceed in length one-fourth the width of the piece. Black knots must not exceed three-fourths of an inch in diameter, and must be especially well set.

121. A six-inch strip twelve feet long shall not contain more than three defects of the extreme sizes. A wider or longer piece may contain relatively more of these defects; and narrower and shorter pieces relatively less. The general appearance of the piece must be taken into consideration.

122. No shake shall be allowed in this grade, but slight season checks and water stain shall not be considered defects.

123. This grade shall be suitable for sound Drop Siding, Ceiling and Flooring, and shall have a smooth appearance, especially on the edges.

No. 1, or Common.

124. The Grade of No. 1, or Common, in boards or strips, includes stock of a generally sound character.

125. Some shake is admissible.

126. Numerous knots, whether red or black.

127. An occasional knot hole in a smooth appearing piece, or in a wide, smooth piece two or three small holes.

128. Some water stain of a firm character.

No. 2, or Sheathing.

129. Boards or strips will admit of considerable shake.

130. Black, unsound knots.

131. Two or three good sized knot holes, or more of small ones.

132. Streaks or patches of discoloration, showing partial decay.

133. The grade can be safely recommended for ordinary sheathing or roof boards.

No. 3, or Cull Boards and Strips.

134. This is the lowest grade made in hemlock.

135. The defects may consist of very excessive shake.

136. Badly shattered stock.

137. Very coarse, unsound knots.

138. A great deal of rot.

139. Excessive cross checks.

PIECE STUFF OR DIMENSION.

No. 1 Dimension.

140. The grade of No. 1 Dimension will admit of shake that will not materially affect the strength of the piece.

141. Also knots, either black or red, that are well located and fairly sound.

142. Or a knot hole that will not impair its strength.

143. Or some slight cross checks, or sound water stain.

144. This grade, while admitting the above defects, must at the same time retain the element of strength required for any ordinary building purposes.

No. 2 Dimension.

145. The grade of No. 2 Dimension includes stock not good enough to be classed as No. 1 and the defects admissible are of the same general character as the defects found in No. 1, except that they are more pronounced.

146. It is the lowest grade recommended for ordinary building purposes.

147. Considerable shake, large unsound knots, loose knots, knot holes, and cross checks are all admissible in this grade, but not a serious combination of these defects in any one piece.

148. This grade can be recommended for cheap construction in small buildings.

Cull Piece Stuff.

149. This grade cannot be recommended for ordinary construction.

150. The defects are very excessive shake, or badly shattered stock, numerous knot holes, very large, coarse, rotten knots, or considerable rot.

Appendix C.

CLASSIFICATION, GRADING AND DRESSING RULES FOR SOUTHERN YELLOW PINE.

1. Southern Yellow Pine.—To cover Long-leaf and Short-leaf Yellow Pine grown in the Southern States.

2. Southern Yellow Pine Lumber shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, except where otherwise expressly stipulated between buyer and seller.

3. Recognized defects in Southern Yellow Pine are knots, knot holes, splits (either from seasoning, ring hearts or rough handling), shake, wane, red heart, pith, rot, rotten streaks, dote, red heart, wormholes, pitch streaks, pitch pockets, torn grain, loosened grain, seasoning or kiln checks and sap, sap stains and imperfect manufacture.

KNOTS.

4. Knots shall be classified as pin, standard and large, as to size; and round and spike, as to form; and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and not over ½ in. in diameter.

6. A standard knot is sound and not over 1½ in. in diameter.

7. A large knot is one any size over 1½ in. in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

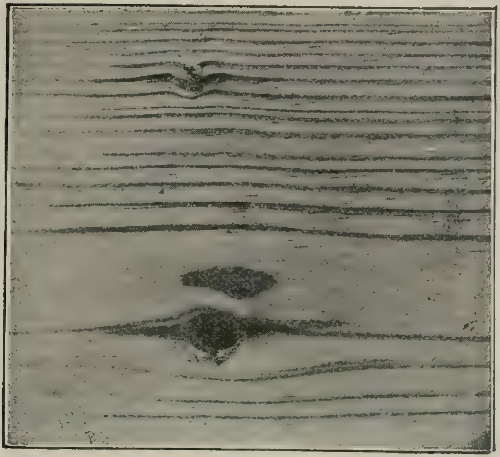
10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is one not held firmly in place by growth or position.

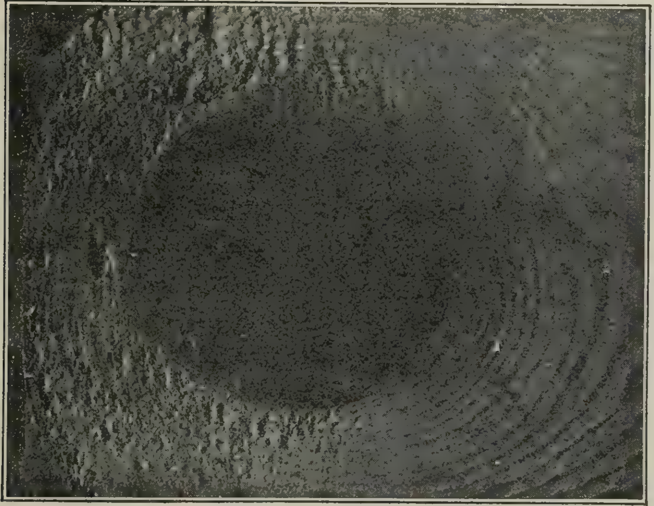
12. A pith knot is a sound knot with a pith hole not more than ¼ in. in diameter.

13. An encased knot is one surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ of an in. in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Sections 10 and 17.)

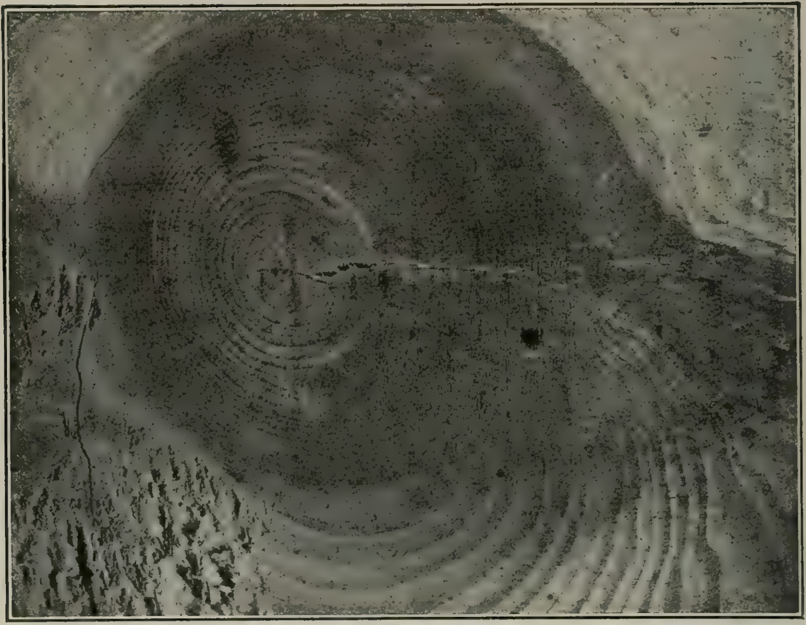
14. A rotten knot is one not as hard as the wood it is in.



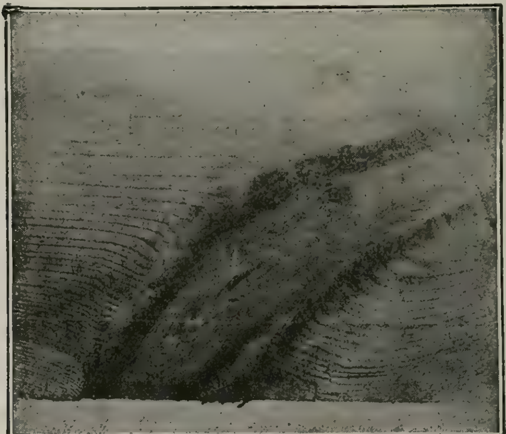
Pin Knot.



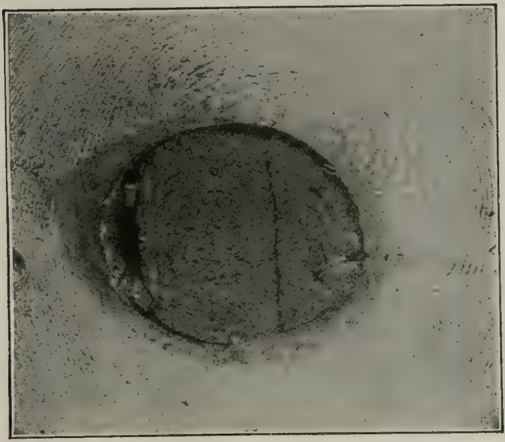
Standard Knot.



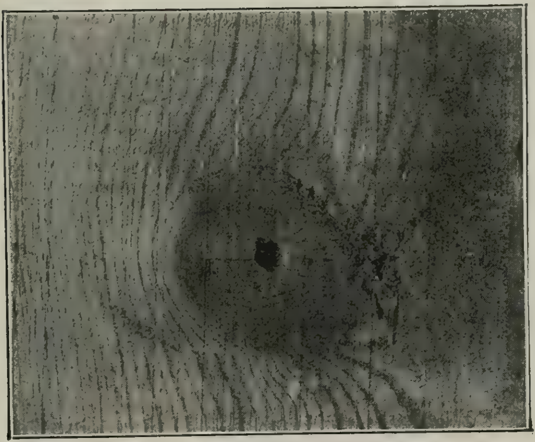
Large Knot.



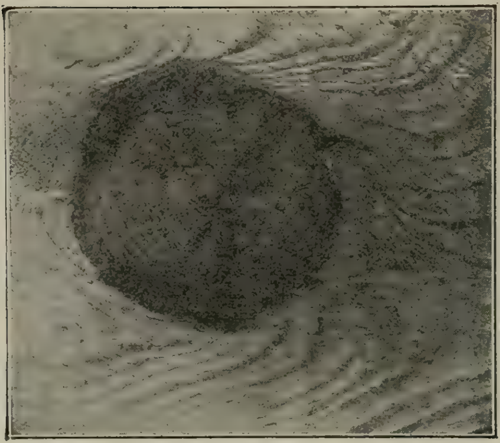
Spike Knot.



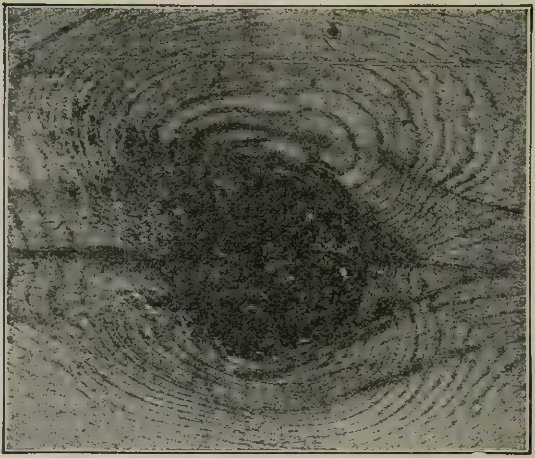
Loose Knot.



Pith Knot.



Encased Knot.



Rotten Knot.

PITCH.

15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an in. wide.

A standard pitch pocket is one not over ⅜ of an in. wide or 3 in. in length.

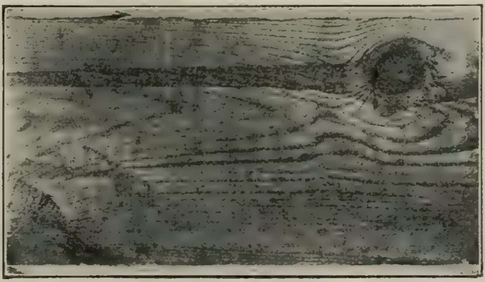
A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

17. A pitch pocket showing open on both sides of the piece ⅛ of an in. or more in width shall be considered the same as a knot hole.

18. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch, it shall not be considered a defect.

19. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.



Pitch Streak.

WANE.

20. Wane is bark, or the lack of wood, from any cause, on the edge.

SAP.

21. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

SHAKE.

22. Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

Through Shake: A shake which extends between two faces of a timber.

Ring Shake: An opening between the annual rings.

23. Sap stain shall not be considered a defect in any of the grades of Common Lumber.

MISCELLANEOUS.

24. Firm red heart shall not be considered a defect in any of the grades of Common Lumber.

25. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

26. All stock except Dimension, shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, or common boards D. & M. or shiplapped and S. 2 S., the best face shall be considered the face side, but the reverse side of all such stock should not be more than one grade lower.

27. Imperfect manufacture in dressed stock, such as torn grain, loosened grain, slight skips in dressing, wane, broken knots, mismatched, insufficient tongue or groove Flooring, Ceiling, Drop Siding, etc., shall be considered defects, and will reduce grade according as they are slight or serious in their effects on the use of the stock.

28. Pieces of Flooring, Drop Siding or Partition with $\frac{3}{16}$-in. or more of tongue; and pieces of Ceiling with $\frac{1}{8}$-in. or more of tongue; and pieces of Shiplap with $\frac{5}{16}$-in. of lap will be admitted in any grade. Pieces of Flooring, Drop Siding, Ceiling or Partition, having not less than $\frac{1}{16}$-in. tongue will be admitted in No. 2 Common. Pieces of Shiplap having less than $\frac{5}{16}$-in. and not less than $\frac{1}{8}$-in. lap shall be admitted in No. 2 common.

29. In all grades of D and better, Flooring, and No. 1 Common and better, Ceiling, Drop Siding, etc., wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece, provided the wane does not extend into the tongue, nor over one-half the thickness below the groove is admissible.

30. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as torn grain and shall not be considered a defect.

31. Torn grain consists in a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters—slight, medium, heavy and deep.

Slight torn grain should not exceed $\frac{1}{32}$ of an inch in depth, medium, $\frac{1}{16}$ of an in., and heavy $\frac{1}{8}$ of an in. Any torn grain heavier than $\frac{1}{8}$ of an in. shall be termed deep.

32. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in Flooring.

33. The grade of all regular stock shall be determined by the number, character, position and location of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest pieces such grades may contain.

34. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended. Material not conforming to standard sizes, for Agricultural Implement Companies, Wagon Companies, Car Manufacturing Companies, Railway Companies, etc., shall be governed by special contract and inspection.

35. The standard lengths are multiples of two ft., ten to twenty-four ft., inclusive, for Boards, Fencing, Dimension, Joists and Timbers; multiples of one foot, ten to twenty ft. inclusive, for Finishing, Flooring, Ceiling, Siding, Partition, Casing, Base Window and Door Jambs—except as hereinafter specified. Longer or shorter lengths than those herein specified are special. Special and fractional lengths, when ordered, shall be counted as the next higher standard length.

36. The standard of widths for lumber, S 1 S or S 2 S or rough, excluding Dimension, shall be multiples of 1 in.—3 in. and up in width.

37. On stock width shipments of No. 1 Common and Better lumber, either rough or dressed one or two sides, no piece should be counted as of standard width that is more than ¼-in. scant on 8-in. and under ⅜-in. scant on 9 and 10 in., or ½-in. scant on 11 and 12-in. or wider. Such pieces should be measured as the next lower standard of width and not reduced in grade. (For widths of No. 2 Boards and Fencing see pp. 70, 71.) (For Dimension see Secs. 84 and 91.)

38. Yellow Pine shall be classified as to grain as Edge Grain and Flat Grain. Edge Grain has been variously designated as rift sawn, vertical grain, quarter sawn, all being commercially synonymous terms. Edge grain stock is especially desirable for Flooring and admits no piece in which the angle of the grain exceeds 45 degrees from vertical at any point, thus excluding all pieces that will sliver or shell from wear. Such as will not meet these requirements shall be known as Flat Grain.

39. All dressed stock shall be measured and sold strip count, viz.: full size of rough material necessarily used in its manufacture.

All sizes 1 in. or less in thickness shall be counted as 1 in. thick.

40. In standard manufacture of Factory Flooring, Decking or thick dressed and matched stock, and stock grooved for splines, and for thick Shiplap, the finished width shall be ½-in. less over all than the count or measured width of the rough material used in manufacture, and the tongue and lap shall be measured to determine the finished width, and face measures shall no longer be standard.

41. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The variations from any given rule are numerous and suggested by practical common sense, so nothing more definite than the general features of different grades should be attempted by rules of inspection. The following, therefore, are sumbitted as the general characteristics of the different grades.

Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or mill work will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

42. The foregoing general observations shall apply to and govern the application of the following rules:

BRIDGE AND TRESTLE TIMBERS.

(See Am. Ry. Eng. and M. of W. annual report, Vol. 10, pp. 198, 1910; for Secs. 43-51.)

(To be applied to single sticks and not to composite members.)

43. General requirements.—Except as noted, all timbers shall be sound, sawed to standard size, square cornered and straight; shall be close grained and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay or other defects that will materially impair its strength.

44. Standard size of sawed timber.—Rough timbers sawed to standard size means that they shall not be over ¼-in. scant from the actual size specified. For instance, a 12 by 12-in. timber shall measure not less than 11¾x11¾ in.

45. Standard dressing of sawed timbers.—Standard dressing means that not more than ¼-in. shall be allowed for dressing each surface. For instance, a 12 by 12-inch timber, after being dressed on four sides, shall measure not less than 11½x11½ in. ffl

Standard Heart Grade—Longleaf Yellow Pine.

46. Stringers.—Shall show not less than 85 per cent. heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer the average depth of sap shall not exceed ½ in. Knots greater than 1½ in. in diameter will not be permitted at any section within 4 in. of the edge of the piece, but knots shall in no case exceed 4 in. in their largest diameter.

47. Caps and sills.—Shall show not less than 85 per cent. heart on each of the four sides, measured across the piece anywhere in the length of the piece; to be free from knots over 2½ in. in diameter.

48. Posts.—Shall show not less than 75 per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece, and to be free from knots over 2½ in. in diameter.

49. Longitudinal struts and girts.—One side shall show all heart; the other side shall show not less than 85 per cent. heart measured across side anywhere in the length of the piece, and shall be free from any large knots or other defects that will materially injure its strength.

50. Longitudinal X braces, sash braces and sway braces.—Shall show four square corners and not less than 80 per cent. heart on each of two faces and shall be free from any large knots or other defects that will materially injure its strength.

51. Ties and guard rails.—Shall show one side all heart; the other side and two edges shall show not less than 75 per cent. heart, measured across the face anywhere in the length of the piece; shall be free from any large knots or other defects that will materially injure its strength, and where surfaced the remaining rough face shall show all heart.

Standard Long and Shortleaf Yellow Pine.

53. Stringers.—Shall be square cornered, with the exception of 1 in. wane on one corner. Knots shall not exceed their largest diameter one-fourth the width of the face of the stock in which they occur and shall in no case exceed 4 in. Ring shakes shall not exceed over one-eighth of the length of the piece.

56. Caps and sills.—Shall be square cornered, with the exception of 1 in. wane on one corner or ½ in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth of the width of the face of the stick in which they occur and in no case shall exceed 4 in. Ring shakes shall not exceed over one-eighth of the length of the piece.

57. Posts.—Shall be square cornered, with the exception of 1 in. wane on one corner; ½ in. wane on two corners. Knots must not exceed in their largest diameter one-fourth of the width of the face of the stick in which they occur, and shall in no case exceed 4 in. Ring shakes shall not extend over one-eighth of the length of the piece.

58. Longitudinal Struts and Girts.—Shall be square edge and sound and shall be free from any large knots or other defects that will materially injure its strength.

59. Longitudinal X Braces, Sash Braces and Sway Braces.—Shall be square cornered and sound and shall be free from any large knots or other defects that will materially injure its strength.

BUILDING LUMBER.

DRESSED YELLOW PINE FINISHING.

64. Sizes. Finishing shall be dressed in the following: 1 in. S. 1 S. or 2 S. to 13/16; 1¼-in. S. 1 S. or 2 S. to 1 1/16; 1½-in. S. 1 S. or 2 S. to 1 5/16; 2-in. S. 1 S. or 2 S. to 1¾ in. 1x4—S. 4 S. shall be 3½ in. wide finished; 1x5—S. 4 S. shall be 4½ in. wide; 1x6—5½ in.; 1x7—6½ in.; 1x8—7½ in.; 1x9—8½ in.; 1x10—9½ in.; 1x11—10½ in.; 1x12—11¼ in. The foregoing widths shall also apply to stock thicker than 1 in.

65. Widths. On stock width shipments of all finishing Lumber, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ¼-in. scant on 8-in. and under; ⅜-in. scant on 9 or 10-in., or ½-in. scant on 11 or 12-in. or wider. Such pieces should be measured as of the next lower standard of width and not reduced in grade.

66. Lengths. Standard Lengths are 10 to 20 ft. and in shipments of mixed lengths, 5 per cent. of 8 or 9 ft. in grade of C and better shall be admitted.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of ft. of each length in such shipment be specifically stated.

Grades A, B and C.

67. A Finishing. Inch, 1¼, 1½ and 2-in., dressed one or two sides, up to and including 8 in. wide, must show one face practically clear of all defects, 9 or 10 in. wide, in addition to one split in end not more than 6-in. long, will admit any one of the following defects: One small pitch pocket; one pin knot; pitch streak or sap stain not to exceed the equivalent of 6 sq. in. One-third of any shipment of 11 and 12-in., in addition to one split in end should not exceed in length the width of the piece, will admit any one of the following defects or its equivalent: Three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one small pitch streak; small seasoning checks; sap stain 1½ in. wide running across the face of the piece.

Thirteen in. and wider will admit two of the above defects or their equivalent. Pieces otherwise admissible, which have loosened or torn grain on the face side, shall be put in a lower grade.

68. B Finishing. Inch, 1¼, 1½ and 2-in., dressed one or two sides up to and including 10 in. in width, in addition to one split in end which should not exceed in length the width of the piece, will admit any two of the following or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; 5 per cent. of sap stain; wane not to exceed 1 in. in width, ¼ in. in depth and 1-6 the length of the piece; small seasoning checks.

Eleven inches and wider will admit three of the above defects or their equivalent; but sap stain shall not exceed 10 per cent.

69. C Finishing. Up to and including 10-in. in width will admit in addition to one split in end which should not exceed in length the width of the piece, any two of the following or their equivalent of combined defects: 25 per cent. of sap stain; 25 per cent. firm red heart; two standard pitch streaks; medium torn grain in three places in one piece; slight shake; seasoning checks that do not go through; two standard pitch pockets; six small pitch pockets; two standard knots; six pin knots; wane 1 in. in width, ½ in. in depth and one-third the length of the piece. Defective dressing will also be allowed that does not prevent its use as finish without waste; 11 and 12-in. will admit one additional defect or its equivalent. Pieces wider than 12 in. will admit two additional defects to those admitted in 10-in. or their equivalent, except sap stain, which shall not be increased.

Pieces otherwise as good as B will admit of 20 pin worm holes.

70. Special. In case both sides are desired A, B or C Grade or free from all defects, special contract must be made. Defective dressing or slight skips in dressing on the reverse side of Finishing are admissible. (See Sections 25, 26 and 29.)

71. Panel Shop. Panel shop is 10-in. and 12-in. wide, all lengths from 8 to 20 ft. or longer. Must be practically free from pitch streaks. May contain any kind of defects that can be removed by cross-cutting the board. Such defects must be limited in number and location so that cross-cutting to remove them will not use more than one-quarter of the length of the piece, and the residue of the piece shall be suitable for No. 1 and No. 2 panel, and all lengths 18-in. and longer, but such residue shall not be considered to be of any special stock length, but will represent the balance of the board after the defects as above named have been removed.

FLOORING.

72. Sizes. D and better, 1x3, 1x4 and 1x6 in. shall be worked to $\frac{13}{16}$x2¼, 3¼ and 5¼ in.; 1¼-in. Flooring shall be worked to 1$\frac{3}{32}$ in. thick; 1½-in. flooring to 1$\frac{11}{32}$ in. thick, the same width and the same matching as 1-in. stock.

73. Lengths. Standard lengths are 8 to 20 ft. in B and Better Flooring with not to exceed 5 per cent. of 8 ft. lengths in mixed length shipments of this grade and in addition 5 per cent. of 6 or 7 ft. in C, D, and No. 1 Common, and 5 per cent. of 4 or 5 ft. in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipments be specifically stated.

74. Grades: A, B, C, D, No. 1 Common, No. 2 Common and No. 3 Sheathing, Flat Grain; and A, B, C, D and No. 1 Common Edge Grain.

75. Special Section. Defects named in Flooring are based upon a piece manufactured from 1x4—12, and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis. Except that standard knots shall not exceed 1¼-in. in diameter in 3-in. flooring.

76. A Flat Flooring must be practically free from defects on the face side and well manufactured.

77. B Flat Flooring will admit any two of the following or their equivalent of combined defects: 15 per cent. Sap stain; 15 per cent. firm red heart; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; slight torn grain; small seasoning checks; six pin worm holes.

78. C Flat Flooring will admit any two of the following defects or their equivalent of combined defects: 25 per cent. of sap stain; 25 per cent. firm red heart; two standard pitch streaks; medium torn grain, or other machine defects that lay without waste; slight shake that does not go through or seasoning checks that do not go through; two standard pitch pockets; six small pitch pockets; two standard knots or six pin knots; 12 pin worm holes.

79. Edge Grain Flooring shall take the same inspection as Flat Grain, except as to the angle of the grain. (See Sec. 36.)

80. Heart Face Edge Grain shall be free from sap on face side.

81. D Flat Flooring will admit the following defects or their equivalent of combined defects: Sound knots not over one-half the cross section of the piece in the rough at any one point throughout its length; three pith knots; pitch; pitch pockets; sap stain; firm red heart; seasoning checks that do not go through; shake that does not go through; a limited number of pin worm holes well scattered; loosened or heavy torn grain, or other machine defects that will lay without waste.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ in. of the length of the piece, provided both pieces are 16 in. or over in length after cutting out such defects.

82. No. 1 Common Flooring is the combined grade of C and D flooring and will admit all pieces that will not grade B and are better than No. 2 Common.

83. No. 2 Common Flooring admits all pieces that will not grade as good as D Flooring, that can be used for cheap floors without a waste of more than one-fourth the length of any one piece. (See Sec. 26.)

84. No. 3 Sheathing will admit of all pieces that cannot be used as No. 2 Common Flooring, but are still available as cheap sheathing or lathing without a waste of more than one-fourth the length of any one piece.

85. Center Matched Flooring shall be required to come up to grade on face side only, and the defects admissible on the reverse side of standard matched shall be allowed.

CEILING.

86. Sizes. Ceiling shall be worked to the following: ⅜ in. Ceiling, $\frac{5}{16}$-in.; ½-in. Ceiling, $\frac{7}{16}$-in.; ⅝-in. Ceiling, $\frac{9}{16}$-in.; ¾-in. Ceiling, $\frac{11}{16}$-in. Same width as Flooring. The bead on all Ceiling and partition shall be depressed $\frac{1}{32}$ of an inch below surface line of piece.

87. Lengths. Standard lengths are 10 to 20 ft. 5 per cent. of 8 or 9 ft. is allowed in mixed length shipments of B and better Ceiling, and in addition 5 per cent. of 6 or 7 ft. in No. 1 Common; and 5 per cent. of 4 or 5 ft. in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of ft. of each length in such shipment be specifically stated.

88. Grades: A, B, No. 1 and No. 2 Common.

89. Special Section. Defects named in Ceiling are based upon a piece manufactured from 1x4—12, and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis.

90. A Ceiling must be practically free from defects on the face side, and well manufactured.

91. B Ceiling will admit of any two of the following defects or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; three small pitch pockets; one standard

pitch pocket; one small pitch streak; small seasoning checks; 15 per cent. sap stain; 15 per cent. firm red heart; 6 pin worm holes.

92. No. 1 Common Ceiling will admit the following defects or their equivalent of combined defects: Sound knots not over one-half the cross-section of piece in the rough; sap stain; pitch streaks; pitch pockets; firm red heart; slight shake; heavy torn grain; seasoning checks; defects in manufacture that will lay without waste; a limited number of pin worm holes, well scattered.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ in. of the length of the piece, provided both pieces are 16 in. or over in length after cutting out such defects.

93. No. 2 Common Ceiling admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece. (See Sec. 26.)

WAGON BOTTOMS.

Sizes.—Unless otherwise ordered (see Section 32), shall be made in sets 38 and 42-in. face, and from stock 4 in. or over in width. Standard thickness shall be $\frac{13}{16}$ in.

Grades: A and B. 58. Wagon Bottoms, unless otherwise ordered (see Section 32), shall be graded the same as A and B Flat Flooring.

DROP SIDING.

94. Sizes. D. and M. shall be worked to ¾x3¼ and 5¼-in. face, 5½-in. over all. Worked Shiplap, to ¾x5-in. face, 3½ and 5½ over all. Patterns that are not shown in Yellow Pine Manufacturers' Association Moulding Book of January, 1908, edition are considered special.

95. Lengths. Standard lengths 10 to 20 ft. Five per cent. of 8 or 9 ft. is allowed in mixed length shipments of B and better Drop Siding, and in addition 5 per cent. of 6 or 7 ft. in No. 1 Common and 5 per cent. of 4 or 5 ft. in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

96. Grades: A, B, No. 1 and No. 2 Common.

97. Special Section. Defects named in Drop Siding are based upon a piece manufactured from 1x6—12 ft. and pieces larger or smaller than this will take a greater or less number of defects, proportioned to their size on this basis.

98. For Grades of 8-in. Barn Siding, see Secs. 69 and 71. For size, see Sec. 111.

99. A Drop Siding must be practically free from defects on the face side and well manufactured.

100. B Drop Siding will admit any two of the following defects or their equivalent of combined defects: Slight torn grain; three pin knots; one standard knot; 15 per cent. sap stain; 15 per cent. firm red heart; small seasoning checks; 6 pin worm holes; or any one of the

above defects, combined with one of the following: Three small pitch pockets or one small pitch streak.

101. No. 1 Common Drop Siding will admit one standard pitch streak or one standard pitch pocket, or their equivalent; and, in addition, sound knots not over one-half the width of piece in the rough; sap stain; firm red heart; slight shake; heavy torn grain; defects in manufacture that will lay without waste; seasoning checks; a limited number of pin worm holes well scattered.

Pieces otherwise as good as B may have one defect (like a knot hole) that can be cut out by wasting 1½ in. of the length of the piece, provided both pieces are 16 in. or over in length after cutting out such defects.

102. No. 2 Common Drop Siding admits of all pieces not as good as No. 1 Common that can be used without waste of more than one-fourth the length of any one piece.

BEVEL SIDING.

103. Size. To be made from stock S. 4 S., worked to 13/16x3½ and 5½ and resawed on a bevel.

104. Lengths. Standard lengths 10 to 20 ft. Five per cent. of 8 or 9 ft. is allowed in mixed length shipments of B and better Bevel Siding, and in addition 5 per cent. of 6 or 7 ft. in No. 1 Common; and 5 per cent. of 4 or 5 ft. in No. 2 Common.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

105. Grades: A, B, No. 1 and No. 2 Common.

106. Bevel Siding shall be graded according to the rules for Drop Siding, and will admit in addition slight imperfections on the thin edge, which will be covered by the lap when laid 2½ and 4½ in. to the weather.

PARTITION.

107. Sizes. Partition shall be worked to ¾x3¼ and 5¼ in.

108. Lengths. Same percentage of short lengths allowed as in Ceiling.

109. Grades: A, B, No. 1 and No. 2 Common.

110. Partition shall be graded according to Ceiling rules, and must meet the requirements of the specified grades on the face side only, but the reverse side shall not be more than one grade lower and shall not cause waste in No. 1 Common and better.

MOLDED CASING AND BASE. WINDOW AND DOOR JAMBS.

111. Sizes of Molded Casing and Base. Shall be worked to ¾-in., as per patterns shown in Yellow Pine Manufacturers' Association Molding Book, 1908 edition. (See Section 37.) For Widths of Plain Casing, see Finishing, S. 4 S.

112. Window and Door Jambs. (See Section 37.) Dressed, Rabbeted and Plowed as ordered.

113. Grades: A, B and C.

114. A Molding Casing and Base must be practically free from defects on the face side and well manufactured.

115. B Casing or Base shall admit the same defects as are admissible in the same widths of B Finishing, except wane. (See Section 42.)

116. C Casing or Base shall admit the same defects as are admissible in the same widths of C Finishing, except wane. (See Section 43.)

117. Window and Door Jambs shall be graded the same as Molded Casing and Base.

See Section 37 for width.

118. B and Better Moldings. One-third of any item may contain any one of the following defects: One pin knot; small pitch pocket; pitch 1 in. wide 6 in. long; slight sap stain covering 6 in. of the length of the piece; three pin worm holes; slight defects in dressing. Standard lengths 8 ft. and longer, and in shipments of mixed lengths, 5 per cent. of 6 or 7 ft. shall be admitted, even though the number of feet of each length in such shipment be specifically stated. Sizes as per Yellow Pine Manufacturers' Association Molding Book, 1908 edition.

COMMON BOARDS, SHIPLAP AND BARN SIDING.

119. Sizes of Boards. 1-in. S. 1 S. or 2 S. to $\frac{13}{16}$, 1¼-in. S. 1 S. or 2 S. to $1\frac{1}{16}$, 1½-in. S. 1 S. or 2 S. to $1\frac{5}{16}$.

120. Widths. On stock width shipments of No. 1 Common, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ¼-in. scant on 8-in. and under; ⅜-in. scant on 9 or 10-in., or ½-in. scant on 11 or 12-in. or wider. Pieces narrower than this should be measured as if of the next lower standard in width and not reduced in grades. Material worked two faces to serve two purposes, like grooved roofing S. 2 S., shiplap S. 2 S., center matched S. 2 S. or one face worked to a pattern, like barn siding, shall be inspected from the best face. 1¼-in. and 1½-in. common shall take the same inspection as 1-in. boards.

Boards S. 4 S. 1x8 S. 4 S. shall be worked 7½ in. wide; 1x9—8½ in.; 1x10—9½ in.; 1x11—10½ in.; 1x12—11¼ in.

121. Sizes of No. 1 Common Shiplap or D. & M. and Barn Siding. 8, 10 and 12-in. shall be worked to $\frac{13}{16}$x7⅛, 9⅛, and 11⅛ in. (See cut, page 35, for standard bead for barn siding.)

122. Grades: No. 1, No. 2, No. 3 and No. 4 Common.

123. No. 1 Common Boards, dressed one or two sides, will admit any number of sound knots, and the mean or average diameter of the knots shall not be more than one-fourth of the cross-section if located on the edge, and shall not be more than one-third of the cross section if located away from the edge; two pith knots; one split not to exceed in length the width of the piece; torn grain; pitch; pitch pockets; slight shake; sap stain; seasoning checks; firm red heart; wane ½-in. deep on edge, not exceeding 1½-in. wide and one-third of the length of the piece or its equivalent, and a limited number of pin worm holes well scattered, or defects equivalent to the above.

124. No. 1 Common Shiplap or D. & M. and Barn Siding shall be graded by rules governing No. 1 Common Boards, except as to wane, which shall not be so deep as to extend into the tongue, or one-half the thickness of the top lip on the groove in D. & M., or over one-half the thickness of the lap in Shiplap on the face side. See Sec. 26.

GROOVED ROOFING.

125. Size of Grooved Roofing. 10 and 12-in. S. 1 S. and 2 E. shall be worked to 13/16x9½ and 11¼.

126. Size of Groove. ½ in. wide, ¼ in. deep and located 1 3/16 in. from outer edge of the groove to edge of board.

127. Grooved Roofing shall be graded by rules governing No. 1 Common Boards, omitting the pith knots, worm holes and splits.

NO. 2 COMMON BOARDS, SHIPLAP, GROOVED ROOFING AND BARN SIDING.

128. Size. 1-in. S. 1 S. or 2 S. to 13/16, 1¼-in. S. 1 S. or 2 S. to 1 1/16, 1½-in. S. 1 S. or 2 S. to 1 5/16.

129. Widths. On stock width shipments of No. 2 common, either rough or dressed one or two sides, no piece should be counted as standard width that is more than ½-in. scant on 8-in. and under; ⅝ on 9 or 10-in., and ¾-in. on 11 and 12-in. or wider. Pieces narrower than this should be measured as the next lower standard in width and not reduced in grades.

130. No. 2 Common Boards, dressed one or two sides, No. 2 Common Shiplap, Grooved Roofing, D. & M. and Barn Siding, will admit knots, not necessarily sound, and the mean or average diameter of the knots shall not be more than one-third of the cross section if located on the edge, and shall not be more than one-half of the cross section if located away from the edge; if sound, may extend one-half the cross section if located on the edge; worm holes; splits one-fourth the length of the piece; through rotten streaks one-fourth the length of the piece, or its equivalent of unsound red heart; through heart shakes, or wane 2 in. wide, one-half the length of the piece, or defects equivalent to the above.

A knot hole 3 in. in diameter will be admitted, provided piece is otherwise as good as No. 1 Common.

131. No. 3 Common Boards, No. 3 Common Shiplap (see Sec. 26), D. & M. and Barn Siding is defective lumber, and will admit of coarse knots, knot holes, very wormy pieces, red rot and other defects that will not prevent its use as a whole for cheap sheathing, or cutting three-fourths its length as No. 2 Common.

132. No. 4 Boards shall include all pieces that fall below the grade of No. 3 Common. It is the lowest recognized grade and it is offered on its merits as defective lumber.

133. Miscut 1-in. Common Boards which do not fall below ¾-in. in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

FENCING. 3, 4, 5 AND 6 IN. WIDE.

134. Sizes. 1-in. S. 1 S. or 2 S. to $\frac{13}{16}$, 1¼-in. S. 1 S. or 2 S. to 1$\frac{1}{16}$, 1½-in. S. 1 S. or 2 S. to 1$\frac{5}{16}$.

135. Widths. On stock width shipments of 3, 4, 5 and 6-in. No. 1 Common, no piece should be counted as standard width that is more than ¼-in. scant in width. Pieces narrower than this should be measured as of the next lower standard in width and not reduced in grades.

136. Grades: No. 1, No. 2, No. 3 and No. 4 Common.

137. No. 1 Fencing will admit the following defects or their equivalent: Sound knots, the mean or average diameter of which shall not be more than one-half the cross section of the piece at any point throughout its length; three pith knots; wane one-half in. deep on edge not exceeding 1½ in. wide and one-half of the length of the piece; torn grain; pitch; pitch pockets; sap stain; seasoning checks; slight shake; firm red heart and a limited number of small worm holes well scattered.

NO. 2 FENCING.

138. Size. S. 1 S or 2 S. to $\frac{13}{16}$-in.

139. Widths. In 3, 4, 5 and 6 in. No. 2 Common stock, no piece shall be counted as standard width that is more than ½-in. scant in width. Such pieces should be measured as of the next lower standard of width and not reduced in grade.

140. No. 2 Fencing, in addition to the defects allowed in No. 1 Common, will admit the following defects or their equivalent: Knots, not necessarily sound, the mean or average diameter of which shall not be more than one-half the cross section if located on the edge, and shall not be more than two-thirds of the cross section if located away from the edge; one split one-fourth the length of the piece; worm holes, through rotten streak one-fourth the length of the piece, shake or wane, but must not cut to waste.

A knot hole 1½ in. in diameter or its equivalent in small hollow knots will be allowed, provided the piece is otherwise as good as No. 1 Common.

141. No. 3 Fencing is defective lumber, and will admit of coarse knots, knot holes, very wormy pieces, red rot and other defects that will not prevent its use as a whole for cheap sheathing, or cutting three-fourths its length as No. 2 Common.

142. No. 4 Fencing shall include all pieces that fall below the grade of No. 3 Common. It is the lowest recognized grade, and it is offered on its merits as defective lumber.

143. Miscut 1-in. Common Fencing which does not fall below ¾-in. in thickness shall be admitted in No. 2 Common, provided the grade of such thin stock is otherwise as good as No. 1 Common.

DIMENSION AND HEAVY JOIST.

144. Sizes. Dimension shall be worked to the following: 2x4 S. 1 S. and 1 E. to 1⅝x3⅝ in.; 2x6 S. 1 S. and 1 E. to 1⅝x5⅝ in.; 2x8 S. 1 S.

and 1 E. to 1⅝x7½ in.; 2x10 S. 1 S. and 1 E. to 1⅝x9½ in.; 2x12 S. 1 S. and 1 E. to 1⅝x11½ in. Dimension S. 4 S. ⅛ in. less in thickness and width than S. 1 S. 1 E. shall be standard, but no objection shall be made to stock finished to the standard size for S. & E.

145. Heavy Joists. Shall be worked to the following: 2x14, 2½ and 3x10, 12 and 14, S. 1 S. and 1 E., green, ¼-in. off side and ½-in. off edge. S. 4 S. ¼-in. off each face surfaced. Heavy Joists, rough, green, must not be over ¼-in. scant in width or thickness.

Dry 2x14 shall be dressed to the standard thickness of 2x12.

146. Grades: No. 1, No. 2 and No. 3 Common.

147. Inspection of Dimension is a question of strength and uniformity of size, and whatever reduces its strength in cross section must be considered a defect to that extent. In computing the area of cross section occupied by defects the size of the piece in the rough shall be considered.

148. No. 1 Common Dimension and Heavy Joists will admit sound knots, none of which in 2x4s should be larger than 2 in. in diameter on one or both sides of the piece, and on wider stock which do not occupy more than one-third of the cross section at any point throughout its length if located at the edge of the piece; or more than one-half of the cross section if located away from the edge; pith knots, or smaller or more defective knots which do not weaken the piece more than the knot aforesaid, will admit of seasoning checks; firm red heart; heart shakes that do not go through; wane ¾ of an in. deep on edge, ¼ the width and ⅓ the length of the piece; pitch; sap stains; pitch pockets; splits in ends not exceeding in length the width of the piece; a limited number of small worm holes well scattered, and such other defects as do not prevent its use as substantial structural material.

149. No. 2 Common Dimension may have knots not necessarily sound, which do not occupy more than one-half of the cross section at any one point if located at the edge of the piece, nor more than two-thirds of the cross section if located away from the edge; smaller, loose, hollow or rotten knots that do not weaken the piece more than the knots aforesaid, will admit rotten streaks; shake; wane; worm holes; split not to exceed ¼ the length of the piece, and other defects which do not prevent its use without waste.

150. No. 3 Dimension will include all pieces falling below No. 2 grade which are sound enough to use for cheap building material, by wasting 25 per cent. of each piece of one-third of number of pieces in any item of a shipment, but it must not be more than ½-in. scant of standard finished width or ⅜-in. scant in thickness. (See Section 31.)

151. Miscut 2-in. Common stock which does not fall below 1½ in. in thickness or ⅛-in. scant in width from standard size, shall be admitted in No. 2 Common, provided such pieces are in all other respects as good as No. 1 Common.

ROUGH YELLOW PINE FINISHING.

152. Widths. On stock width shipments of C and better finish, either rough or dressed one or two sides, no piece should be counted

as standard width that is more than ¼-in. scant on 8-in. and under; ⅜-in. scant on 9 and 10-in., or ½-in. scant on 11 and 12-in or wider. Such pieces should be measured as the next lower standard of width, and not reduced in grade.

153. Lengths. Standard Lengths are 10 to 20 ft., and in shipments of mixed lengths 5 per cent. of 8 or 9 ft. in grades of C and better shall be admitted.

The above per cent. is allowed in all shipments of mixed lengths, even though the number of feet of each length in such shipment be specifically stated.

154. Finish must be evenly manufactured, and shall embrace all sizes from 1 to 2 in. in thickness by 3 in. and over in width.

155. No inch, 1¼ and 1½ finishing lumber, unless otherwise ordered, shall measure when dry more than 1/16-in. scant in thickness; on 2-in. it may be ⅛-in. scant.

156. Wane and seasoning checks and other defects that will dress out in working to standard thickness and widths are admissible.

157. Subject to the foregoing provisions, Rough Finishing shall be graded according to the specifications applying to dressed finishing lumber.

158. All finishing lumber ordered rough, if thicker than the count thickness for dry or green stock, may be dressed to such count thickness and when so dressed shall be considered as rough.

When like grade on both faces is required, *special contract* must be made.

COMMON BOARDS, FENCING AND DIMENSION.

159. Rough Common Boards and Fencing should not be less than ⅞-in. thick when dry.

160. Rough 2-in. Common should not be less than 1⅞ in. thick when green, or 1¾ in. thick when dry. The several widths should not be less than ⅛-in. over the standard dressing width for such stock when dry.

161. Rough Common Dimension of a greater thickness than 2 in. and less than 4 in. shall be subject to special contract as to thickness and width.

162. Rough Dimension, if thicker than specified thickness for dry or green stock, may be dressed to such standard thickness, and when so dressed shall be considered as rough stock.

163. The defects admissible in Rough Boards, Fencing and Dimension shall be the same as those applying to dressed stock of like kind and grade, and such further defects as would disappear in dressing to standard sizes of such material shall be allowed.

NO. 1 COMMON TIMBERS. (Not to include bridge and trestle timbers.)

164. Sizes. Common Timber shall be worked to the following: 4x4, 4x6, 6x6, ⅜-in. off side and edge. Surfaced 4 sides, ¼-in. off each side, 6x8 and larger S. 4 S., ¼-in. off each side surfaced.

165. Rough Timbers, 4x4 and larger, shall not be more than ¼-in. scant at any point when green, and be well manufactured, with not less

than three square edges, and will admit sound knots that do not occupy more than one-third the cross section of the piece or small defective knots.

Timbers 10x10 in size may have a 2-in. wane on one corner, measured on faces, or its equivalent on two or more corners one-third the length of the piece. Larger sizes may have proportionately greater defects.

Shakes extending not over one-eighth of the length of the piece are admissible, and seasoning checks shall not be considered a defect.

166. Dressed Timbers shall conform in grading to the specifications applying to rough timbers of same size.

167. Rough Timbers, if thicker than specified thickness for dry or green stock, may be dressed to such standard thickness, and when so dressed shall be considered as rough stock.

168. Yellow Pine Plastering Lath. No. 1 should measure 2-in. in thickness to every five lath, green, the minimum thickness of any one lath shall not be less than 5/16 of an in., green, and should not be less than 1 7/16 in. in width, green, length 4 ft., 1⅝ in. thickness to every 5 lath, dry, and should not measure less than 1 5/16 in. in width, dry. Will admit wane ⅛ of an in. deep, ¼ of an in. on face, and 6 in. long, pin worm holes and one pin knot. Must not be more than ½ of an in, scant in length. Blue sap stain shall not be considered a defect.

169. No. 2 shall consist of pieces that fall below the grade of No. 1 which are not less than 1¼ in. in width, ¼ of an in. thick, when dry, and are not more than ¾ of an in. short in length. Will admit wane; worm holes; knots and other defects that will not prevent their use the entire length without waste.

BYRKIT LATH.

170. Size. ¾x3½ and 5¼ in. wide, lengths 4 ft. and upward.

171. Standard Byrkit Lath shall consist of material that will be held firmly in place and support plaster by ordinary nailing by not wasting more than 10 per cent. of any piece, and that will present a full surface with no openings over ½ in. in width and 3 in. in length. The ends of pieces of Byrkit Lath are not expected to meet on studding, and only such quantity shall be counted waste as is necessary to remove a defect.

STANDARD SIZES OF DRESSED LUMBER.

172. Finishing shall be dressed to the following: 1-in. S. 1 S. or 2 S. to 13/16; 1¼-in. S. 1 S. or 2 S. to 1 1/16; 1½-in. S. 1 S. or 2 S. to 1 5/16; 2-in. S. 1 S. or 2 S. to 1¾ in. 1x4 S. 4 S. shall be 3½ in. wide finished; 1x5 S. 4 S. shall be 4½ in. wide; 1x6—5½ in.; 1x7—6½ in.; 1x8—7½ in.; 1x9—8½ in.; 1x10—9½ in.; 1x11—10½ in.; 1x12—11¼ in.

The foregoing widths shall also apply to stock thicker than 1 in.

173. Molded Casing and Base. Shall be worked to ¾-in. as per patterns shown in Yellow Pine Manufacturers' Association Molding Book, 1908 edition.

174. Flooring. The standard of 1x3, 1x4 and 1x6 in. D and better shall be worked to 13/16x2¼, 3¼ and 5¼ in. (see cut on page 26); 1¼-in.

Flooring shall be $1\frac{3}{32}$ in. thick; 1½-in. Flooring to $1\frac{11}{32}$ in. thick, the same width and matching as 1-in. stock.

175. Drop Siding. D. and M. shall be worked to ¾x3¼ and 5¼ in. face, 4½ and 5½ over all. Worked Shiplap, ¾x5-in. face, 5½ over all. Patterns that are not shown in Yellow Pine Manufacturers' Association Molding Book of January, 1908, edition are considered special.

176. Ceiling shall be worked to the following: ⅜-in. Ceiling, $\frac{5}{16}$ in.; ½-in. Ceiling, $\frac{7}{16}$ in.; ⅝-in. Ceiling, $\frac{9}{16}$ in.; ¾-in. Ceiling, $\frac{11}{16}$ in. Same width as Flooring. The standard working of Ceiling shall be beaded center and edge, with slight bevel on groove edge. (See cuts on pages 27 and 28.) The bead on all Ceiling and Partition shall be depressed $\frac{1}{32}$ of an in. below surface line of piece.

177. Partition shall be worked to the following: ¾x3¼ and 5¼ in. Same standard for location of and size of bead as applies to ceiling. (See Section 106 and cut on page 26.)

178. Bevel Siding. To be made from stock S. 4 S. worked to $\frac{13}{16}$x3½ and 5½ and resawed on a bevel.

179. Window and Door Jambs. (See Section 37.) Dressed, Rabbeted and Plowed as ordered.

180. Boards and Fencing. 1-in. S. 1 S. or 2 S. to $\frac{13}{16}$-in.

181. Shiplap and Barn Siding No. 1 Common. 8, 10 and 12-in. shall be worked to $\frac{13}{16}$x7⅛, 9⅛ and 11⅛ in.

182. D. and M. No. 1 Common. 8, 10 and 12-in. shall be worked to the following: $\frac{13}{16}$x7⅛, 9⅛ and 11⅛ in.

183. Grooved Roofing. 10 and 12-in. S. 1 S. and 2 E. shall be worked to $\frac{13}{16}$x9½ and 11¼. (See page 15 for size and location of Groove, and cut on page 36.) Wagon Bottoms left out.

184. Dimension shall be worked to the following: 2x4 S. 1 S. and 1 E. to 1⅝x3⅝ in.; 2x6 S. 1 S. and 1 E. to 1⅝x5⅝ in.; 2x8 S. 1 S. and 1 E. to 1⅝x7½ in.; 2x10 S. 1 S. and 1 E. to 1⅝x9½ in.; 2x12 S. 1 S. and 1 E. to 1⅝x11½ in. Dimension S. 4 S. ⅛-in. less than standard size S. 1 S. and 1 E.

185. Heavy Joists (not to include bridge and trestle timbers) shall be worked to the following: 2x14, 2½ and 3x10, 12 and 14, S. 1 S. and 1 E., green, ¼-in. off side and ½-in. off edge. S. 4 S. ¼-in. off each face surfaced. Heavy Joists, rough, green, must not be over ¼-in. scant in width or thickness.

186. Heavy Flooring. For 2 and 2½-in. matching the thickness should be ⅜ of an in. less than the rough material. The tongue should be ⅜-in. thick and ⅜-in. long. For 3-in. and thicker matching the tongue should be ¾-in. thick and ⅜-in. long, and the thickness of the stock should be ⅜-in. less than the rough material. The groove in heavy matchings should be $\frac{1}{16}$-in. wider than the thickness of the tongue, and $\frac{1}{16}$-in. deeper than the length of the tongue. Tongue and groove shall be located ¼ the thickness of the rough material from the bottom of the piece. In 2 in. and thicker material plowed for splines the groove should be the same width and depth as is provided for in matching material of the same thickness.

Heavy shiplap shall be worked to the same thickness as heavy flooring. The lap shall be ½-in. long, occuping one-half the finished thickness of the piece.

Timbers shall be worked to the following: 4x4 and larger, S. 1 S. or S. and E., ⅜ in. off each face surfaced; S. 3 S. or S. 4 S., ¼ in. off each face surfaced.

187. Yellow Pine Plastering Lath. No. 1 should measure 2 in. in thickness to every five lath, green, the minimum thickness of any one lath shall not be less than $\frac{5}{16}$ of an inch green, and should not be less than 1$\frac{7}{16}$ in. in width, green, length 4 feet; 1⅝ in. thickness to every 5 lath, dry, and should not measure less than 1$\frac{5}{16}$ in. in width, dry. Must not be more than ½ in. scant in length when dry.

188. No. 2 must not be less than 1¼ in. in width, ¼ in. thick, when dry, and not more than ¾ in. short in length.

189. Byrkit Lath. ¾x3½ and 5¼ in. wide lengths, 4 ft. and upward.

PICKETS.

190. Square Pickets. From 1½-in. stock shall be worked to 1$\frac{5}{16}$x1$\frac{5}{16}$, 3 and 4 ft. long, dressed on four sides and pointed. From 1¼-in. stock shall be worked to 1$\frac{1}{16}$x1$\frac{1}{16}$, 3 and 4 ft. long, dressed on four sides and pointed.

191. Flat Pickets. From 1x3 stock shall be worked to ¾x2¼, 3 and 4 ft. long, dressed on four sides and headed.

Appendix D.

STANDARD SPECIFICATIONS FOR CONSTRUCTION OAK TIMBERS.

GENERAL INSTRUCTIONS.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large per cent. is above the grade described.

Definition of Oak for Construction Purposes.

The term "Construction Oak" means all such products of oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak":

Firsts are to be sound and free from heart, shakes and checks, but may have other defects as follows:

I.—CONSTRUCTION OAK.

(A) Trestle and Bridge Timbers: Mud Sills, Stringers, Caps, Posts, Bracing, Bridge Ties, Struts, Guard Rails, Girts, Sash and Sway Braces.

(B) Docking and Platform Timbers: Mud Sills, Posts, Bracing, Caps, Stringers, Joists, Dock and Platform or Flooring Plank, Wales.

(C) Platform or Flooring Plank can be either square edged or matched.

(F) Ties: Switch Ties.

(G) Framing for Building: Mud Sills, Posts, Girders, Framing Joists, etc.

(H) Bridge and Crossing Plank: Railroad Crossing Plank, Bridge Floor Planking.

(H-a) Sheet Piles: Same as Crossing Plank, except may contain unlimited amount of heart.

(H-b) Round Piling.

(I) Cattle Guards.

(J) Track or Bumper Post.

Items A, B, C, G hereafter designated as Structural Oak.

II.—STANDARD DEFECTS.

Definition "Defect": Fault, blemish, mark of imperfection that will materially injure the strength.

Measurements which refer to the diameter of knots or holes shall be considered as referring to the mean or average diameter.

II.—(A) KNOTS.

(1) Sound Knot. A Sound Knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be any color and contain checks.

(2) Loose Knot. A Loose Knot is one not firmly held in place by growth or position.

(3) Pith Knot. A Pith Knot is a Sound Knot with a pith hole not more than ¼-in. in diameter in the center.

(4) Rotten Knot. A Rotten Knot is one that is not sound and not as hard as the wood surrounding it.

(5) Pin Knot. A Pin Knot is a Sound Knot not over ¾-in. in diameter.

(6) Standard Knot. A Standard Knot is a knot not over 2-in. in diameter.

(7) Large Knot. A Large Knot is a Sound Knot more than 2-in. in diameter.

(8) Round Knot. A Round Knot is one which is oval or circular in form.

(9) Spike Knot. A Spike Knot is one sawn in lengthwise direction. The mean or the average width shall be considered in measuring this knot.

(10) Bird Peck. Bruises apparently caused by bird pecks during the growth process of the timber. Considered no defect.

II.—(B) WORM DEFECTS.

(1) Pinworm Holes. Pinworm Holes are very small holes caused by minute insects or worms. These holes usually are not over 1/16-in. in diameter, or smaller, and the wood surrounding them is sound and does not show any evidence of the wormhole having any effect on the wood other than the opening.

(2) Spotworm Defects (also known as Flagworm Defects). Spotworm defects are caused like Pinworm Holes, by minute insects or worms working on the timber during its growth. The size of the hole is about the same as Pinworm Holes, but the surrounding wood shows a colored spot as evidence of the defect. This spot is usually sound and does not affect the strength of the piece.

(3) Grubworm Holes. Grubworm Holes are usually from about ¼-in. to ½-in. in width, and vary in length from about 3/16-in. to 1-in. long, and are caused by worms working in the wood.

(4) Wooden Rafting Pinholes. This defect sometimes appears on river timber which has been rafted and holes bored in the solid wood for tying the timber, and a solid plug or pin driven in the hole, filling it completely. These defects must be treated and considered the

same as Knot Defects. Ordinary Metal, Rafting Pin or Chain Doghole is considered no defect.

II.—(C) SAP.

Definition of "Sap": The Alburnum of a tree—the exterior part of the wood next to the bark—Sapwood, not considered a defect.

Sound Heart: The term Sound Heart is used in these rules whenever heart of piece is split or opened and shows on outside of piece and its condition is sound and solid, not decayed. Openings between annual rings or checks not considered a defect.

II.—(D) WANE.

Wane is bark or lack of wood from any cause on edges of timber.

II.—(E) SHAKES.

Definition of "Shakes": Shakes are splits or checks in the timber which usually cause a separation of the wood between the annual rings.

(1) Ring Shakes. Ring Shakes are openings between the annual rings, usually showing only on the end of timber.

(2) Through Shakes. Through Shakes are shakes which extend between two faces of the timber.

(3) Checks. A small crack in the wood due to seasoning, not considered a defect.

II.—(F) GRAIN.

Crooked or Crossgrain. Crooked or Crossgrain crosses the piece within a section 24-in. in running length of the piece. This is only considered a defect in certain smaller sizes of dimension for specific purposes.

II.—(G) ROT.

Any form of decay which may be detected as giving the timber a doty or rotten texture is a rotten defect, including what is commonly known as dryrot. Water Stain, or what are sometimes called scalded or burnt spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burnt spots where the timber is improperly piled green, not considered defects, as they do not affect the strength of the piece.

III.—STANDARD NAMES FOR CONSTRUCTION OAK.

Standard Names for Construction Oak Timber: White Oak and Red Oak. Unless specially mentioned these terms include the following:

- White Oak:
  - White Oak.
  - Chestnut or Tanbark Oak.
  - Burr or Mossy Cup Oak.
  - Rock.
  - Post or Iron Oak.

- Overcup.
- Live Oak.
- Cow Oak.
- Swamp Post Oak.
- Yellow or Chinquapin Oak.

Red Oak:

- Red Oak.
- Pin Oak.
- Black Oak.
- Water Oak.
- Willow Oak.
- Spanish Oak.
- Turkey Oak.
- Black Jack Oak.
- Shingle or Laurel Oak.
- Scarlet Oak.

Term.—Mixed Oak means any kind of Oak.

IV.—STANDARD SPECIFICATIONS FOR STRUCTURAL OAK TIMBERS.

(1) General Requirements. Except as noted, all Structural Timbers shall be White Oak, to be sound timber and sawed specified sizes; free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote and wane in amounts greater than allowed in these specifications.

(2) Boxed Hearts. Boxed Hearts are permitted in pieces of 5x5 square and larger. The center of the heart should be boxed as near the center of the piece as practical, and not to exceed 30 per cent. of the pieces can have the center of the heart nearer than 1½-in. from any face; 20 per cent. may show one heart face, corner or edge, not to exceed 75 per cent. of the length of the piece.

IV.—(3) WANE.

(a) Pieces 5x5 to 8x8 square may show 1-in. wane, side measurement, on any two corners or edges, and this wane not to exceed more than 25 per cent. of the length of the piece singly, or 50 per cent. in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(b) Pieces over 8x8, including 12x12 square, may show 1½-in. wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent. of the length of the piece singly, or 66⅔ per cent. in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 66⅔ per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(c) Pieces over 12x12 square may show 1¾-in. side measurement, any two corners of edges, and this wane not to extend more than

40 per cent. of the length of the piece singly, or 80 per cent. in aggregate. In the absence of wane on all corners, excepting one, the one corner may contain wane 80 per cent. of the length of the piece as above described; not to exceed 20 per cent. of number of pieces may have this defect.

(d) In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

(e) Pieces 1-in. to 5-in. thick, not exceeding 8-in. wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent. of pieces 2-in. and thicker may show sound heart on one face; pieces under 2-in. thick must be free of heart. Pieces 8-in. and wider may contain wane as per paragraphs b and d.

(f) Rough sizes of Structural Timber shall not vary more than ¼-in. scant of specified size. Dressed sizes may be ½-in. scant after dressing.

Explanatory.

The term 20 per cent. of number of pieces or amount shipped refers to each item and size of each car shipped.

V.—(D) TIES.

(1) Switch Ties Sawed. Thickness cut to order; widths cut to order; lengths cut to order; unless noted to be White Oak. Must contain three sound solid sides. One face or one corner (not both) may show sound heart. Large sound knots, pin, spot, or an occasional grubworm hole not considered a defect. Sizes may vary ½-in. from specified sizes.

V.—(E) BRIDGE, DOCK, CROSSING PLANK.

Lengths, cut to order.

Widths, cut to order.

Thickness, cut to order.

Sizes cut to order, probably 2-in., 3-in. and 4-in. thick, 6-in., 8-in., 10-in. and 12-in. wide, 12 ft., 14 ft. and 16 ft. long.

This product is intended to work full one good sound face, and this face side must be square edge. Sound knots, small pin and spot-worm holes no defect on face side.

Must be free from rot and shake; practically square edges, admitting 1-in. of wane on each edge of reverse face, running two-thirds the length. Sound hearts on one side, rafting pinholes, knotholes or grubholes not exceeding 2-in. in diameter admitted.

V.—(F) SHEET PILES.

Same as V.—(E), except that it may contain sound heart or heart check.

V.—(G) CATTLE-GUARDS.

To be governed by specifications for Construction Oak, reference IV.

V.—(H) TRACK END OR BUMPING POSTS.

To be governed by specifications for Structural Timbers, reference IV.

DISCUSSION.

(The report of the Special Committee on Rules for Grading and Inspection of Maintenance of Way Lumber was presented by Mr. W. H. Sellew, Principal Assistant Engineer, Michigan Central Railroad, Chairman.)

Mr. W. H. Sellew:—The Committee wants to call attention to the fact that the information given is presented only as a matter of information. The names of timber and definitions of defects are practically those adopted last year by the Master Car Builders', Master Mechanics', and Railway Storekeepers' Associations, in conference with the Manufacturers of Lumber, and are substantially the same as all the present standard definitions of this Association. All reference to car and locomotive material is omitted, and specifications for maintenance of way lumber, as formulated by the Manufacturers' Associations, are submitted. Owing to the fact that considerable attention has been given by other committees of the Association to this subject, it was felt desirable to proceed with a good deal of caution. For this reason, no revision of the specifications submitted to the Committee by the lumber manufacturers was attempted. With the exception of the specification for Douglas fir structural timber, page 32, we are undoubtedly buying considerable material under these rules, and it will be necessary to study them carefully before recommendations can be made for grading rules that may be adopted as the joint standard of this Association and the various manufacturing associations throughout the country.

The President:—The report of this Committee in is the nature of information. They submit no conclusions or recommendations, and the report is now before you for discussion, or such action as you may wish to take. The Committee has done valuable work. The Maintenance of Equipment Department of railroads has established a set of grading rules, and it has been considered very important that the Maintenance of Way Department do likewise. That was the purpose of the formation of this Special Committee, and in the very short time in which they have been formed, they have done a most creditable work, as their report indicates.

Mr. Chas. S. Churchill (Norfolk & Western):—Does the Committee expect to get their methods adopted by those who furnish lumber? Will this be agreed to?

Dr. Hermann Von Schrenk (Consulting Timber Engineer):—The idea of the Committee was to request the various Manufacturers' Associations to present concrete rules for the various classes of railroad material under which they would be able to furnish railway lumber. The chief criticism which the Committee has found hitherto was that the lumber manufacturers generally criticized the railway specifications, saying that they were numerous and various; that what they would like to see was a standard specification for each class of lumber adopted by the railway organizations. The Committee therefore requested that the manufacturers' associations submit such specifications as they believed should be standard. These specifications have been printed preliminary to their general adoption, and the lumber manufacturers' associations have on their part agreed that unless they are very materially changed, they would issue them as standard specifications on their part.

Mr. Churchill:—I move that this report be received in the manner suggested by the Committee as information.

The President:—Before the motion is put, we have with us Mr. J. H. Waterman, the President of the Railway Storekeepers' Association, who will address us on this important subject. (Applause.)

Mr. J. H. Waterman:—We appreciate very much your kindness in allowing us to present to you for your consideration a question which we believe is vital to your Association and to the railroads which you represent, namely, Uniform Grading and Inspection of Lumber.

The credentials which we bring are from the Railway Storekeepers' Association. At their sixth annual convention, 1909, there were several papers presented on the Uniform Grading and Inspection of Lumber. After this question had been discussed thoroughly by the organization referred to, the following resolution was passed:

"Resolved, That a Committee of five be appointed by the President to confer with the Master Car Builders' and Master Mechanics' Associations, and request the adoption by them of the commercial grading rules as the standard of lumber specifications by the railroads."

The members of the Committee were: Mr. McCarthy, of the Rock Island, Chairman; Mr. Rice, of the Santa Fe; Mr. Mulroy, of the St. L. & S. F.; Mr. Jones, of the New York Central; Mr. Waterman, of the C., B. & Q.

This Committee in 1909 went to Atlantic City and attended the Master Car Builders' and Master Mechanics' conventions, presented the resolution, and succeeded in having a committee appointed from each Association to act jointly with the committee from the Railway Storekeepers' Association to draft standard specifications to cover all classes of lumber used in cars and locomotives.

The committee met several times and was assisted very materially by the manufacturers' associations—North, South, East and West. The facts are the manufacturers were very glad to co-operate with the joint committee referred to above and to change any of the established rules which they had to conform with the rules which the committee felt were best.

This enabled the committee to make a complete report to the convention of the Master Car Builders' and Master Mechanics' Associations which met at Atlantic City in 1910 and present standard specifications for all classes of lumber used in cars and locomotives. This report was adopted unanimously by both the Master Mechanics' Association and the Master Car Builders' Association.

In August, 1910, we learned that the American Railway Engineering and Maintenance of Way Association had appointed a Committee on Rules for the Grading and Inspection of Maintenance of Way Lumber.

We immediately wrote your President, Mr. Fritch, on August 23, and offered your Committee, through him, any information which we had gathered in connection with our work in preparing the standard specifications which were adopted by the Master Mechanics' and Master Car Builders' Associations.

On August 30 your President acknowledged receipt of the letter and advised:

"I wish to thank you for your letter and will instruct our Committee to avail themselves of your kind offer."

We have had the pleasure of meeting with your Committee during the past year and have given them what assistance we had at hand.

The question arises: Why should we have standard specifications for lumber?

First, in order that you may appreciate some of the difficulties which the Purchasing Departments and the Store Departments are up against in furnishing material for maintenance of way, you are aware that every road or nearly every road in the country have their own specifications, and no two specifications are alike.

This necessitates the lumbermen from whom the lumber is purchased treating every order they get as a special order. The reason it is termed a "special order" is because it is not standard in a commercial sense, or to put it another way, it differs from the recognized commercial practice as exemplified in the standard grading rules adopted by the associations of lumber manufacturers.

One road will insist on having all their flooring center-matched. The standard practice is to match it a little off the center. This for buildings and for other purposes to get the most wear out of the material which is ordinarily used for flooring.

One of our large Western lines which runs through a territory which supplied them with oak for years had the lumber inspected at the mill without specification. Some one decided it would be better to have a specification for oak. They drafted a specification for oak, describing the quality they were then receiving, and sent the same inspectors to the mills, with the result that the price was immediately advanced from three to five dollars per thousand and some of the mills did not care to cut the order at all.

This may seem ridiculous; however, it is true, as every man knows who has the purchasing or receiving and inspecting of lumber.

This also shows you the trouble which is always experienced with railroads who undertake to accept lumber other than grades of the Lumbermen's Association. The reasons are as stated above; they are termed "specials."

To illustrate, a man who is building a home can go into the market and get what is termed stock size of moulding, we will say, for picture moulding; however, he wants a little different moulding than what is termed a standard. The price is immediately doubled and tripled. Why? Because it is a "special." All special orders result in higher prices.

Let the government build a building and the architect make special specifications for the lumber which is to be used in the building. Immediately the price is advanced from five to ten dollars per thousand, according to the specifications and grades used. I have this from a lumberman who is my personal friend, who often figures bills for the Government.

Second, aside from that—and we think this is a good reason why we should have uniform inspection and grading of lumber—it often happens that lumber shipped by the same manufacturer to two or more points on the same railroad will get satisfactory inspection from one point and a very unsatisfactory inspection from the other points. Why? Because the men receiving the lumber construe the specifications differently.

You say, "Would not the same thing be true if the railroads in ordering material adopted standard specifications as promulgated by the Lumbermen's Association?" It would not, for this reason: if the lumbermen were dissatisfied with the inspection which they received, they could immediately appeal to the Lumbermen's Association from the district from which the material was shipped and have a licensed inspector or what they term an official inspection made of the car, and if the inspector rejected the car, they would have to stand it; if he accepted the car, the company would have to receive it.

In other words, when the railroad companies of this country adopt specifications of their own there is no way by which a lumberman who accepts and furnishes the lumber can get an official inspection because the railroad immediately says, "We interpret our specifications 'so and so,'" and they are the highest authority.

This results in another difficulty in purchasing lumber. If a lumberman is selling a bill of lumber and he knows he cannot obtain an official inspection, any number of them refuse the order and this brings the number who bid on the bill down to a very few, and you have less competition, and for that very reason you pay a higher price for the goods you receive.

Each and every one of you appreciate what is termed to-day "blueprints," and you in your line of work are compared with some other men in the same line by the management of your roads. If one railroad purchases lumber on the specifications which the Lumbermen's Association draft and your Purchasing Agent purchases the lumber on the specification of your road, the former has the advantage, and then you are asked why you cannot build depots, buildings and bridges as cheap as your neighbors.

Third, gentlemen, there is one point I want to make very clear to you and that is this: You are the users of the lumber, you have a perfect right to elect the class and kind of lumber you shall use for a special purpose, and we, representatives of the Purchasing and Store Departments of the railroads, do not want to be construed, or misconstrued, as attempting to dictate to you gentlemen what class of lumber you should use for a given purpose.

We appreciate, and no doubt you do, that the railroads of this country use 40 to 50 per cent. of all the lumber that is manufactured, and we appreciate that the men at the head of the Engineering Departments of the various railroads should say what kind of lumber should be used for a special purpose.

However, if you will take the rules and specifications which have been adopted by the various lumber manufacturing associations of the United States, North, South, East and West, see the Appendix to your Committee's report "A," "B," "C" and "D," depending entirely on the territory from which you draw your supply; we believe that you can select from their rules and specifications material which will in every way satisfy your wants, and can select material which can be bought more easily and at very much less money, and that is what we are all striving for, not to get the cheapest for the company which we represent, because it is the cheapest, but to get the best we can get for the least money.

That is why we come before you asking you to take some action endorsing, if you can, what your Committee has done and continuing the same with authority. We will co-operate with them, if you think that best. However, we leave that for you to elect.

We hope that in the very near future there may be a standard specification adopted which will be uniform, and let me emphasize here, and I want to make it clear that as we run we may read, that we do not expect any rules or specifications that will say a certain kind of lumber or grade of lumber must be used by all roads for the same purpose. In other words, we do not want to be understood that we are advancing a proposition that all roads should use the same class of lumber in the same place. This would be suicide, but what we want is this:

We would like the American Railway Engineering and Maintenance of Way Association in their own way to say that as the various lumbermen's manufacturing associations of the United States have adopted rules and specifications for the grading of all classes of lumber which we use, the railroads will accept these grading rules as their standard for the inspection of all lumber which they buy, and designate the lowest grade inspected under the commercial grading rules, which will be acceptable to the railroads of this country for each particular purpose.

To illustrate, see Appendix "A;" you can order select stringers or standard stringers; select caps and sills or standard caps and sills; select posts or standard posts. See Appendix "B," you have three grades of siding to select from, "A," "B" and "C." You have four grades of flooring, "A," "B," "C" and "D." In ordering any of the material referred to above, the use of the same would have two or more grades from which to select, each one electing what grade would be most suitable for his road or the purpose for which he intends using the same.

Favorable action by the American Railway Engineering and Maintenance of Way Association can result in only one thing; greater ease, more uniformity, less frequent disputes in connection with the inspection of lumber, and a greater certainty of an adequate supply being promptly secured, especially in busy times.

Gentlemen, we appreciate the time which you have given us to present this question, and we are sure that we could present it to a no more intelligent body of men, and if the Committee representing the Railway Storekeepers' Association can be of any assistance, we will gladly give you any information which we have. Gentlemen, I thank you. (Applause.)

The President:—I am sure that I voice the sentiments of the convention when I express our hearty thanks to Mr. Waterman for his admirable paper.

Mr. W. McC. Bond (Baltimore & Ohio Southwestern):—Within the last six or nine months I have had occasion to be in a position to realize some of the good effects that would result from a standard for maintenance of way lumber. The Baltimore & Ohio has the past year repaired a good many miles of second and third-class track, and they have needed a good deal of maintenance of way lumber, switch timbers and bridge lumber for special or temporary work. I personally know that orders were placed for lumber, and at the end of six months that lumber was not furnished, and the railroad company had to ship lumber from west of the Alleghanies to the east side of the Alleghanies to get the work done at the specified time. I think it would be a great saving in many ways to the railroads to have a standard under which one road could buy the same lumber from a mill that the other would, and the stock would be the same, that each road would want to use.

(The motion carried.)

The President:—The Committee will be dismissed with the thanks of the Association.

REPORT OF COMMITTEE IX.—ON SIGNS, FENCES AND CROSSINGS.

(Bulletin 130.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The following subjects were assigned to your Committee for the year 1910 by the Board of Direction:

1. Consider revision of Manual; if no changes are recommended, make statement accordingly.
2. Report on ways and means for securing a proper quality of fence wire to resist corrosion and secure durability.
3. Continue investigation of the use of concrete fence posts, and submit recommendations.
4. Continue investigation as to the best form of track construction and flangeways in street crossings and paved streets.

No meetings of the Committee were held during the year. The demands on the time of the Chairman were so heavy that he found it impossible to attend any meeting, and called none. The work has been carried on by correspondence.

The Committee submits the following report on the several subjects assigned to it:

1. REVISION OF MANUAL.

No changes are recommended, further than those submitted in the report for 1909, which your Committee recommends be adopted and included in the Manual.

2. REPORT ON THE WAYS AND MEANS FOR SECURING A PROPER QUALITY OF FENCE WIRE TO RESIST CORROSION AND SECURE DURABILITY.

On this subject the Committee has been energetic in pursuing its investigations, placing itself in close touch with progress, scrutinizing and testing out every new theory advanced pertaining to the preservation of wire, and proving its merits or demerits. In its researches and investigations, it has had the assistance of the most practicable and most scientific bodies in the country familiar with the subject. Thus far, however, no new process has been discovered which offers any advantage over the old, and it is the opinion of the Committee that the applied galvanized coating, by special treatment, is the best and only known economical process for protecting wire used in railroad fences against corrosion.

CONCLUSION.

We recommend the use of wire which has received a special galvanized coating to stand a test of four one-minute immersions in the standard copper sulphate solution, the galvanizing to be done preferably after weaving.

3. CONCRETE FENCE POSTS.

The tests, observations and use of concrete fence posts during the current year indicate:

(1) That concrete fence posts are practicable, durable and economical.

(2) The eight-foot post is recommended.

(3) Posts of cross-section approaching a square form are easiest made and most suitable for fencing.

(4) Spacing, same as recommended for wood posts.

(5) Stone or gravel used in mixing concrete for fence posts should pass a half-inch square mesh. Concrete should be mixed wet, in a batch mixer, and poured into the molds. The poured posts are a little over 25 per cent. stronger than tamped posts of the same size, mixture and reinforcement; they are also better able to withstand the action of frost and alkali. Experience shows that extra precaution should be used in the selection of material, mixing of concrete, and handling and curing the posts. For the best results, posts should be allowed to remain in the yard undisturbed for at least sixty days after coming from the molds.

(6) Breakage in handling and transportation should not exceed three-tenths of one per cent.

CONCLUSION.

Concrete fence posts are recommended for railroad fences.

4. CONSTRUCTION OF FLANGEWAYS IN STREET CROSSINGS AND PAVED STREETS.

On this subject the Committee can only report progress. The Sub-committee having it in hand have worked hard to formulate plans and make recommendations, but the subject is of so much importance, the Committee feel that more time should be given for their investigation.

Respectfully submitted,

W. D. Williams, Chief Engineer, Cincinnati Northern Railroad, Van Wert, O., *Chairman.*

K. J. C. Zinck, Assistant Engineer, Grand Trunk Pacific Railway, Winnipeg, Manitoba, *Vice-Chairman.*

A. M. Funk, Division Engineer, Baltimore & Ohio Railroad, New Castle, Pa.

W. H. Hoyt, Assistant Chief Engineer, Duluth, Missabe & Northern Railroad, Duluth, Minn.

E. R. Lewis, Division Engineer, Michigan Central Railroad, Bay City, Mich.

Joseph Mullen, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Mattoon, Ill.

W. J. Burton, Division Engineer, Missouri Pacific Railway, St. Louis, Mo.

C. H. Stein, Engineer Maintenance of Way, Central Railroad of New Jersey, Jersey City, N. J.

E. J. Steinbeck, Assistant Engineer, Illinois Central Railroad, Chicago, Ill.

Committee.

DISCUSSION.

(In the absence of the Chairman, the report on Signs, Fences and Crossings was presented by the Vice-Chairman, Mr. K. J. C. Zinck, of the Grand Trunk Pacific.)

Mr. K. J. C. Zinck:—But little progress has been made by your Committee during the past year. Quite a number of things have to be taken up more thoroughly, and the Committee therefore asks that the Association refer this report back to them for further work during the coming year. I make a motion to that effect.

The President:—You have heard the motion. You will note that the Committee has made certain recommendations, but without further consideration, they think it is proper to refer the matter back to the Committee in order that they may make a more complete report next year.

(The motion carried.)

The President:—The Committee is relieved, with the thanks of the Association.

REPORT OF SPECIAL COMMITTEE ON UNIFORM GENERAL CONTRACT FORMS.

(Bulletin 133.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Special Committee on Uniform General Contract Forms presents progress report as follows:

The Committee was instructed by the Board of Direction to take up the following work during the current year:

(1) Review and revise uniform general contract forms presented at Tenth Annual Convention.

(2) Make concise recommendations for next year's work.

General meetings of the Committee were held as follows:

At New York City, January 20, 1911, attended by J. C. Irwin, Chairman; E. F. Ackerman, W. G. Atwood, E. H. Lee, C. A. Wilson.

At Buffalo, February 4 and 5, 1911, attended by J. C. Irwin, Chairman; E. F. Ackerman, W. G. Atwood.

The Committee has thoroughly considered the report made at the Tenth Annual Convention in 1909 and published in Bulletin 108, and has made a study of the principal contracts in use. The plan of having an agreement form of two pages separate from the general contract conditions and as referred to on page 1176 of the Proceedings of the Tenth Annual Convention, is approved by this Committee, and the agreement form presented in that report has been reconsidered and revised and is presented herewith with recommendations for adoption.

In small or unimportant contracts this agreement form, which is designated as Form A, may be used alone, but in larger contracts the "General Conditions" statement designated as Form B may be inserted, using the agreement form as a folder with the introductory page at the beginning of the contract and the signatures at the end.

Specifications relating to the particular work can either be included in the folder or attached to the back.

The Committee has, in the agreement, made the "Contractor" the party of the first part, and the "Company" the party of the second part and has, therefore, in preparing the "General Conditions," placed the provisions relating especially to the duties and rights of the "Contractor" first and those relating to the duties and rights of the "Company" last.

The Committee has considered and presented herewith, for discussion, twenty-eight proposed sections as follows:

1. Bond.
2. Contractor's Understanding.
3. Intent of Plans and Specifications.
4. Permits.
5. Protection.
6. Rights of Various Interests.
7. Consent to Transfer.
8. Superintendence.
9. Timely Demand for Points and Instructions.
10. Report Errors and Discrepancies.
11. Preservation of Stakes.
12. Inspection.
13. Defective Work or Material.
14. Indemnity.
15. Settlement for Wages.
16. Liens.
17. Work Adjacent to Railroad.
18. Risk.
19. Order and Discipline.
20. Contractors Not to Hire Company's Employes.
21. Intoxicating Liquors Prohibited.
22. Cleaning Up.
23. Engineer and Chief Engineer Defined.
24. Power of Engineer.
25. Adjustment of Dispute.
26. Order of Completion; Use of Completed Portions.
27. Changes.
28. Extra work.

And has outlined for future meetings the formation of the remaining sections, which, in general, will cover the following items:

Property and Right of Entry.
Temporary Suspension of Work.
Annulment.
Measurement and Approval of Work.
Estimates and Payments.

CONCLUSIONS.

The Committee especially presents for approval:

(1) The general scheme of having the two-page general agreement, Form A, as a folder within which the other portions of the contract can be bound, thus permitting a concise contract form or a large contract form, according to the requirements of the case.

(2) The agreement—Form A—as presented herewith.

The Committee presents for discussion and suggestions:

(1) The scheme of arrangement of B—General Conditions.

(2) The composition of the 28 sections above enumerated.

For next year's work it is recommended that preparation of a standard contract form be continued on the lines already begun.

Respectfully submitted,

J. C. Irwin, Chief Engineer, Rutland Railroad, Rutland, Vt., *Chairman.*

W. G. Brimson, Vice-President and General Manager, Quincy, Omaha & Kansas City Railway, Kansas City, Mo., *Vice-Chairman.*

E. F. Ackerman, Assistant Engineer, Lehigh Valley Railroad, New York, N. Y.

F. H. Alfred, General Superintendent, Cincinnati, Hamilton & Dayton Railway, Cincinnati, Ohio.

Wm. Archer, Assistant Engineer Maintenance of Way, Baltimore & Ohio Southwestern Railroad, Cincinnati, Ohio.

William Ashton, Chief Engineer, Oregon Short Line, Salt Lake City, Utah.

W. G. Atwood, Chief Engineer, Lake Erie & Western Railroad, Indianapolis, Ind.

W. L. Breckinridge, Engineer Maintenance of Way, Chicago, Burlington & Quincy Railroad, Chicago, Ill.

E. H. Lee, Chief Engineer, Chicago & Western Indiana Railway, Chicago, Ill.

F. W. Smith, Engineer of Construction, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, Ohio.

W. F. Tye, Civil Engineer, Toronto, Can.

C. A. Wilson, Consulting Engineer, Cincinnati, Ohio.

Committee.

CONSTRUCTION CONTRACT.

A—AGREEMENT.

THIS AGREEMENT, made this .... day of .... in the year .... by and between .... party of the first part, hereinafter called the Contractor, and .... party of the second part, hereinafter called the Company.

WITNESSETH, That, in consideration of the covenants and agreements hereinafter mentioned, to be performed by the parties hereto and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The Contractor will furnish all the necessary transportation, materials, superintendence, labor and equipment and will execute, construct and finish in an expeditious, substantial and workmanlike manner to the satisfaction and acceptance of the Chief Engineer of the Company.
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in accordance with the plans hereto attached or as hereinafter described and the following general conditions, requirements and specifications, forming part of this agreement.

The work covered by this contract shall be commenced ....and be completed on or before the .... day of .... 191.., ...
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And in consideration of the completion of the work described herein, and the fulfillment of all the stipulations of this agreement to the satisfaction and acceptance of the Chief Engineer of the Company, the said Company, its successors or assigns hereby agree to well and truly pay, or cause to be paid, to said Contractor, the executors, administrators, successors or assigns of said Contractor, as the case may be, the amount due the Contractor, based on the following prices..............

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IN WITNESS WHEREOF, The parties hereto have dulv executed this instrument in duplicate the day and year first above written.

WITNESS:

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CONSTRUCTION CONTRACT.

B. GENERAL CONDITIONS.

Bond.

1. The Contractor agrees, at the time of the execution and delivery of this contract and before the taking effect of the same, to furnish and deliver to the Company a good and sufficient bond of indemnity to the amount of .... dollars, as security for the faithful performance, by the Contractor, of all the covenants and agreements on the part of the Contractor contained in this contract. The security in such bond of indemnity must be satisfactory and acceptable to the Company.

This bond shall remain in force and effect in such amount, not greater than that specified, as shall be determined by the Chief Engineer, until the final completion and acceptance of the work.

Contractor's Understanding.

2. It is understood and agreed that the Contractor has satisfied himself by careful personal examination as to the nature and location of the work, the form of the surface of the ground, the character, quality and quantity of the materials to be encountered, the character of the plant, structures, equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way influence this contract, and no information upon any such matters derived from the maps, plans, profiles, drawings or from any source whatever, shall in any way affect any risk or obligation, or relieve him from fulfilling any of the terms of this agreement. No verbal agreements or conversations with any officer, agent or employe of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

Intent of Plans and Specifications.

3. All work that may be called for in the specifications and not shown on the plans, or shown on the plans and not called for in the specifications, is to be executed and furnished by the Contractor as if described in both these ways; and should any work or material be required which is not denoted in the specifications or plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intentions thereof, the Contractor is to understand the same to be implied and required, and is to perform all such work and furnish any such material as fully as if they were particularly delineated or described.

Permits.

4. The Contractor shall, at his own cost and expense, except as specifically provided in this contract, secure the necessary permits for the work included in this contract and will be responsible for violations of any laws, rules or regulations.

Protection.

5. Whenever the local conditions, laws or ordinances require, the Contractor shall furnish and maintain, at his own cost and expense, necessary passageways, guard fences and lights and such other facilities and means of protection as may be required.

Rights of Various Interests.

6. Wherever work being done by Company forces or by other Contractors is contiguous to work covered by this contract, the respective rights of the various interests involved shall be determined by the Engineer, to secure the completion of the various portions of the work in general harmony.

Consent to Transfer.

7. The Contractor agrees not to let or transfer this contract or any part thereof (except for the delivery of material) without consent of the Chief Engineer, given in writing. Such consent does not release or relieve the Contractor from any or all of his obligations and liabilities under this contract.

Superintendence.

8. The Contractor agrees to constantly superintend all the work embraced in this contract in person or by a duly authorized manager acceptable to the company.

Timely Demand for Points and Instructions.

9. The Contractor shall not proceed until he has made previously timely demand upon the Engineer for, and received from him, such points and instructions as may be necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

Report Errors and Discrepancies.

10. If the Contractor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors in plans or in the layout as given by said points and instructions, it shall be his duty to immediately inform the Engineer. Any work done after such discovery, until verified, will be done at the Contractor's risk.

Preservation of Stakes.

11. The Contractor must carefully preserve bench marks, reference points and stakes, and in case of wilful or careless destruction he will be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

Inspection.

12. All work and materials shall at all times be open to the inspection, acceptance or rejection of the Engineer or his duly authorized representative. The Contractor shall at all times provide sufficient safe and proper facilities for such inspection.

Defective Work or Material.

13. Any omission or failure on the part of the Engineer to disapprove or reject any work or material shall not be construed to be an acceptance of any defective work or material. The Contractor shall remove, at his own expense, any work or material condemned by the Engineer, and shall rebuild and replace any work or material so condemned without extra charge, and in default thereof the same shall be done by the Company at the Contractor's expense—or in case the Chief Engineer should not consider the defect of sufficient importance to require the Contractor to rebuild or replace any imperfect work or material, he shall have power, and is hereby authorized, to make any deduction from the stipulated price that he may see proper.

Indemnity.

14. The Contractor agrees to indemnify and save harmless the Company for and from all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against it, for or on account of any injuries or damages received or sustained by any party or parties by reason of any act or omission of the said Contractor, his agents or employes, in the construction of said work or by or in consequence of any negligence or carelessness in guarding the same.

Settlement for Wages.

15. Whenever, in the opinion of the Chief Engineer, it may be necessary or conducive to the progress of the work to secure to any of the employes of the Contractor any wages which may then be due them, the Company is hereby authorized to pay such laborers the amount due them or any lesser amount, and the amounts so paid them, as shown by their receipts, shall be deducted from any moneys that may be or become payable to said Contractor.

Liens.

16. If at any time anyone employed by the Contractor, either to perform work as a sub-contractor or laborer or otherwise, or to furnish any materials, shall file or give notice of any mechanic's or other liens therefor, the Company is hereby authorized to pay and discharge the same if it shall deem best so to do, and to deduct the amount so paid from any moneys which may be or become due and payable to the Contractor.

Work Adjacent to Railroad.

17. Whenever the work embraced in this contract is near the tracks, structures or buildings of this Company or of other railroads, the Contractor shall use extraordinary care and vigilance to avoid injury to persons or property. The work must be so conducted as not to interfere with the movement of trains or other operations of the railroad; and if in any case such interference be necessary, the Contractor shall not proceed until he has first obtained specific authority and directions therefor from the proper officer of the Railroad Company and has the approval of the Engineer.

Risk.

18. The work in every respect shall be at the risk of the Contractor until finished and accepted.

Order and Discipline.

19. The Contractor shall at all times enforce strict discipline and good order among his employes, and any employe of the Contractor who shall appear to be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer, and he shall not again be employed on the work without the Engineer's written consent.

Contractor Not to Hire Company's Employes.

20. The Contractor shall not employ or hire any of the Company's employes.

Intoxicating Liquors Prohibited.

21. The Contractor shall not permit the sale, distribution or use of any intoxicating liquors upon or adjacent to the work, or allow any such to be brought upon, to or near the line of the railway of the Company.

Cleaning Up.

22. The Contractor must, before the work is finally accepted, at his own expense, clear away from the Company's property and from all public and private property all temporary structures, rubbish and waste materials resulting from his operations.

Engineer and Chief Engineer Defined.

23. Wherever in this contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.

Power of Engineer.

24. The Engineer shall have full power to reject or condemn all work or material which, in his opinion, does not conform to this agreement; to direct the application of forces to any portion of the work which in his judgment requires it; to order the force increased or diminished, and to decide every question that may arise between the parties relative to the execution of the work.

Adjustment of Dispute.

25. All questions, differences or controversies which may arise between the Contractor and the Company, under or in reference to this agreement, or its performance or non-performance, or the work to which it relates or in any way whatever pertaining to or connected with said work, shall be subject to the decision of the Chief Engineer, and his decision shall be final and conclusive to both parties.

Order of Completion; Use of Completed Portions.

26. The Contractor shall complete any portion or portions of the work in such order of time as the Engineer may require. The Company shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of the work so taken or used or any part thereof. If such prior use increases the cost of the work, the Contractor will be entitled to such extra compensation as the Chief Engineer may determine.

Changes.

27. The Company shall have the right to make any changes that may be hereafter determined upon, in the nature or dimensions of the work, either before or after its commencement, and such changes shall in no way affect or void this agreement, but the difference in the value of the work shall be adjusted by the Engineer. If such changes diminish the quantity or extent of the work to be done, they shall not, under any circumstances, be construed as constituting, and shall not constitute, a claim for damages or for anticipated profits on such work.

In case of any work being done under a lump-sum contract price, and the quantity of work actually furnished upon completion of the work should vary and prove more or less than the quantities shown on the original plans and provided for by the specifications, then the contract lump-sum price is to be adjusted in the final payment accordingly. If the contract provides a schedule of unit rates for variations in the work, then the adjustment is to be made on the basis of such unit rates, either adding or deducting the corresponding amounts according to whether the quantity of each class of work was increased or decreased over the amounts originally covered by the lump-sum bid; if the contract does not contain such a schedule of unit rates, then the value of all such additions or omissions is to be established by the Engineer, and the adjustment made accordingly.

Extra Work.

28. No bill or claim for extra work or material shall be allowed or paid unless the doing of such extra work or the furnishing of such extra material shall have been authorized in writing by the Engineer, and the price to be paid fixed by the Chief Engineer in writing before any part of such work was done or material furnished.

The Chief Engineer, in fixing the price for the doing of work or the furnishing of material not provided for in this agreement, may either fix a unit price or a lump-sum price or may, if he so elects, provide that the price shall be determined by the actual cost, to which shall be added .... per cent to cover general expense and superintendence, profits, contingencies, use of tools, Contractor's risk and liability. If the Contractor shall perform any work or furnish any material which is not provided for in this agreement, or which was not authorized in writing by the Engineer previous to the doing of the work or the furnishing of material, said Contractor shall receive no compensation for such work or material so furnished, and does hereby release and discharge the Company from any payment therefor.

If the Contractor shall proceed with such extra work or the furnishing of such extra materials after receiving the written authority therefor, as hereinbefore provided, then such work or material, stated in the written authority of the Engineer shall be covered, governed and controlled by all the terms and provisions of this agreement, subject to such prices as may be agreed upon or determined by the Chief Engineer.

If the Contractor shall decline or fail to perform such work or furnish such extra material as authorized by the Engineer in writing, as aforesaid, the Company may then arrange for the performance of the work in any manner it may see fit, the same as if this agreement had not been executed, and the Contractor shall not interfere with such performance of the work.

(The report on Uniform General Contract Forms was received as information.)

REPORT OF COMMITTEE XIX.—ON CONSERVATION OF NATURAL RESOURCES.

(Bulletin 133.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The following report of the Committee on Conservation of Natural Resources is submitted as a report of progress.

Three meetings of the Committee were held during the year, two at the Congress Hotel, Chicago, on March 16 and 17, and one in the office of the Chairman on March 18. At these meetings an outline of work for the coming year was agreed upon.

On March 17 the Board of Direction notified the Chairman of the Committee that it would be constituted one of the Standing Committees, under the title of "Committee on Conservation of Natural Resources."

Under date of July 1, 1910, the Chairman received from Mr. B. N. Baker, President, National Conservation Congress, notice of meeting of the Second National Congress, to be held in St. Paul, September 6 to 9, inclusive, in which this Committee was invited to make a report to be read before the National Conservation Congress.

A delegation, consisting of five members of the Committee, was appointed by President Fritch to represent the Association at the convention.

In pursuance of the request from President Baker, the following report was transmitted to Mr. Thos. R. Shipp, Executive Secretary of the National Conservation Congress, on September 3, 1910, by the Chairman:

"In October, 1908, the National Conservation Commission invited the American Railway Engineering and Maintenance of Way Association, in connection with other technical bodies of this country, to be represented at the conference held in Washington and to assist the National Conservation Commission with suggestions concerning advisable lines of inquiry, nature of report to be made, and possibilities of accomplishment on the part of the Commission.

"Acting upon this invitation, the Board of Direction of the Association appointed a Special Committee to co-operate with the Commission. This Committee consisted of eight members of the Association, selected from widely-separated sections of the country. The Association, through this Committee, was represented at the Joint Conservation Congress held in Washington, beginning December 8, 1908, and the Committee has been keeping in touch with the conservation movement through Mr. Gifford Pinchot and the Secretary, Mr. Thos. R. Shipp. Several meetings of the

Committee have been held, and in March, 1909, the Committee was addressed by Dr. Jos. A. Holmes.

"In March, 1909, the Committee, through its Chairman, requested Mr. Pinchot to furnish, through co-operation with the Forestry Department, suggestions as to the best methods to be pursued by the railroad companies for the prevention and control of forest fires, with statistics of the loss from such cause, and urged upon the Commission the importance of endeavoring to effect reduction in the tariff on cross-ties and lumber rates, in order to make it possible for the railroad companies to import ties and save thereby the home supply.

"The co-operation of the Committee was offered with the Forest Products Laboratory at the University of Wisconsin or with any of the national or state organizations.

"On May 13, 1909, an elaborate report was transmitted to the Committee by the National Conservation Commission, through its Secretary, Mr. Shipp, containing valuable suggestions as to the possibilities of railroad companies assisting the work of conservation by thorough methods of prevention and control of forest fires, and the cultivation of timber for railroad purposes, the use of sawed instead of hewed ties, the use of treated timber, and the necessities for the extension of the supply of creosote, and other features relating to timber resources. This report was transmitted by the Committee to the American Railway Engineering and Maintenance of Way Association, published by the Association, and distributed throughout the country in one of its bulletins.

"Dealing directly, as it does, with those features of conservation that affect the railroad companies and their patrons, and having a circulation among railroad officers covering the United States, as well as large portions of Canada and Mexico, the results should be exceedingly beneficial to the cause of conservation.

"In March of this year the American Railway Engineering and Maintenance of Way Association, recognizing the growing importance of the conservation movement, established the Special Committee as one of the Standing Committees of the Association, at the same time largely increasing the personnel, and bringing into membership a number of prominent railroad officers of this country and Canada.

"The work of the Committee has been divided into Sub-Committees for the purpose of specialization, with an outline for investigation as follows:

(1) Tree planting and general reforestation.
(2) Coal and fuel oil resources.
(3) Iron and steel resources.

A sub-division of the work, as per statement following, was recommended:

(1) *Tree Planting and General Reforestation.*
    (a) Extent of existing forests considered in connection with increase of growth and consumption.

- (b) Judicious selection of tree varieties for planting, the locality and soil conditions considered. Possibility of value from growth on cut-over land.
- (c) Methods of planting and cultivation, with cost of same, considering possibilities from cut-over lands.
- (d) Anticipated results at maturity from trees so produced.
- (e) Methods and cost of caring for and protecting existing forests.

(2) *Coal and Fuel Oil Resources.*

- (a) Extent of existing supplies, considered in connection with consumption.
- (b) Extent of waste in production.
- (c) Economic consumption, giving consideration to practical use of by-products.

(3) *Iron and Steel Resources.*

- (a) Supplies of raw material, considered in connection with consumption.
- (b) Waste in production.
- (c) Best methods of protecting finished products from destructive influences.

"The Committee will continue on the lines of investigation as shown, and holds itself in readiness to co-operate with the National Conservation Commission and its kindred and subsidiary organizations, as well as other national societies, for the furtherance of the great principles of conservation of the national resources."

The very serious forest fires that occurred in the fall of 1910 were the subject of thorough discussion at a meeting of the Lake States Forest Fire Conference, held in St. Paul under the auspices of the Minnesota State Forestry Board and Minnesota Forestry Association, Tuesday and Wednesday, December 6 and 7. This was a representative meeting, there being about 100 delegates in attendance, including lumber interests, members of various forestry associations and railroad officials, twelve railroads being represented. While this Committee was not invited to attend this meeting, the Chairman was invited to do so as a railroad official, but, being unable to attend, sent a representative; and on account of the interest of the railroads of this section in the subject under discussion, and its importance in connection with the conservation of natural resources, the following resolutions, which were formally adopted at that conference, are given:

"Resolved, That we recommend to the legislatures of our states:

"(1) That the forest fire protection of each state and such other branches of state work as may be deemed best to combine with it, be placed under the control of a non-partisan commission, empowered, as fully as possible under the constitutions of the different states, to carry on the work, and under civil service rules. Such commission should represent all the interests involved, as far as possible, and we recommend that such commission place the work in charge of a chief forester, who should be a professional graduate forester, and that the commission employ such trained foresters and other assistants as may be necessary; define their duties and fix their salaries; said employes to be engaged under civil service regulations as the commission may prescribe.

"(2) Resolved, That it is the sense of this conference that the present Forest Fire Warden Service of Michigan, Wisconsin and Minnesota is totally inadequate to meet the existing fire hazard to both life and property, and that forest protection service, to become efficient, must be greatly extended. To this end we recommend an adequate Forest Patrol System, maintained by the state, organized and operated by the Commission referred to.

"(3) We further recommend, That the Commission be authorized to co-operate with the National Government, the several adjoining states and such associations and organizations as the Commission may find necessary to best protect the timber resources of the state.

"(4) Resolved, That this conference is opposed to a general slash-burning law, as experience has proven it unsatisfactory, impracticable and dangerous. We recommend, however, that the Commission should be given authority to order the disposal of dangerous slashings sufficient to establish a safe fire line around standing timber or other valuable property.

"(5) Resolved, That this conference advocates legislation providing strict regulation of the burning of brush and debris in clearing land during the dry season, such burning to be under the direction of state fire patrolmen, under such regulations as the Commission may prescribe.

"(6) We further recommend, That the burning of all debris on the rights of way of the various railroads be under the control and direction of the State Forest Patrol. Further, That under special conditions directed by the State Forest Patrol, the railway companies maintain a patrol, properly equipped, following their trains; also that all railroad and logging locomotives and traction engines must be equipped with the most practical spark-arresting devices (subject to inspection and approval of the Commission).

"(7) Whereas, The building of fire lines around exposed property, including settlements, villages and towns, has proven a most effective means for the control and extinguishment of fires, we recommend that one of the principal duties of the patrolmen working under the direction of the Commission should be to establish such fire lines where necessary for protection of property.

"(8) We recommend, as the most effective measures for preventing and fighting serious fires, adequate means of transportation and communication, to include trails, telephone lines and lookout stations, and that the efforts of the Commission should be exerted toward the construction and establishment of the same as rapidly as consistent.

"(9) The appalling sacrifice of life and the continued great loss of state and private property, resulting from fires in our forested area, are a disgrace to our civilization and a most serious drain upon our natural resources, and we believe that the expenditure of such amount as may be necessary to prevent these losses is fully justified.

"We therefore recommend, That the appropriations by the state legislatures to maintain forest protection should be sufficient to provide for a forest patrolman for each forty thousand acres requiring protection, as well as for the expenses necessary to successfully carry out all of the measures suggested by these resolutions.

"(10) We recommend, in addition to the patrol system, an auxiliary county fire-fighting force to be appointed by and under the direction of the Commission, to be paid by the state and charged back to the counties, such expense to be ultimately borne by the counties or towns in which the fires occur.

"Further be it, resolved, That as it is shown by statistics that there are a large number of fires set each season through the carelessness of the general public, including campers, fishermen, hunters and others, we recommend that a campaign of education be energetically carried on through every possible channel to the end that this hazard be reduced through a better understanding of forest conditions by all the people.

"Resolved, further, That the sincere thanks of all the delegates and attendants here be extended to the officials of the state of Minnesota and and the city of St. Paul, who have contributed so largely to the success of this conference, to the Manufacturers' and Jobbers' Association of St. Paul for the courtesies shown, to the management of the St. Paul Hotel for the facilities so freely extended, and to the press for its treatment of the proceedings of the Lake States Forest Fire Conference."

Request has been made that the members of the Committee on Conservation be supplied with report of the proceedings of this meeting, which is to be printed and gotten out by the National Lumbermen's Association.

On account of the wide variance in location of members of the Committee, it has not been practicable to hold subsequent meetings of the Committee since the ones above mentioned, but the Committee will continue to keep in as close touch as possible with the subject of Conservation of Natural Resources, and to co-operate with the National Conservation Commission, and its kindred and subsidiary organizations, as well as other national societies, in the furtherance of this work.

Respectfully submitted,

A. S. Baldwin, Chief Engineer, Illinois Central Railroad, Chicago, *Chairman.*

E. O. Faulkner, Manager, Tie and Timber Department, Atchison, Topeka & Santa Fe System, Los Angeles, Cal., *Vice-Chairman.*

Moses Burpee, Chief Engineer, Bangor & Aroostook Railroad, Houlton, Me.

W. A. Bostwick, Metallurgical Engineer, Carnegie Steel Company, Pittsburg, Pa.

F. F. Busteed, General Superintendent, Canadian Pacific Railway, Vancouver, B. C.

E. B. Cushing, Engineer of Construction, Sunset Central Lines, Houston, Tex.
W. F. H. Finke, Tie and Timber Agent, Southern Railway, Washington, D. C.
J. W. Kendrick, Vice-President, Atchison, Topeka & Santa Fe System, Chicago.
A. L. Kuehn, General Superintendent, American Creosoting Company, Chicago.
G. A. Mountain, Chief Engineer, Canadian Railway Commission, Ottawa, Can.
William McNab, Principal Assistant Engineer, Grand Trunk Railway, Montreal, Can.
C. L. Ransom, Resident Engineer, Chicago & Northwestern Railway, Omaha, Neb.

Committee.

(The report was received as a progress report.)

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